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Computing today

FEBRUARY 1984
85p

MACHINE CODE MADE EASIER
Monitor review for the Spectrum

MULTI-TASKING ZX81-FORTH – Can it do the job?

Sounding off on the Commodore 64

Getting to grips with Epson printer graphics

Debugging random number software with non-random sequences

Two useful utilities for PET programmers


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All material should be typed. Any programs submitted must be listed (cassette tapes and discs will not be accepted) and should be accompanied by sufficient documentation to enable their implementation. Please enclose an SAE if you want your manuscript returned, all submissions will be acknowledged. Any published work will be paid for.

All work for consideration should be sent to the Editor at our Charing Cross Road address.

CONSUMER NEWS

SV ARRIVAL

The powerful Spectravideo range of personal computers, currently enjoying a huge sales success in the US, is now available for the first time in the UK. Distributed exclusively by CK Computers of Weston-super-Mare, Avon, the Spectravideo range comprises two models, the SV318 and SV-328.

A major selling feature of both Spectravideo machines is their adoption of the MSX specification, which is expected to become the industry standard for home computers. MSX uses Microsoft BASIC as its resident interpreter and gives access to a wealth of computer games and other personal computer software. In addition, the SV-318 and the SV-328 are also CP/M compatible, which means that as users' demands become more sophisticated they can take advantage of the comprehensive range of software programs written for CP/M such as Wordstar and Visicalc.

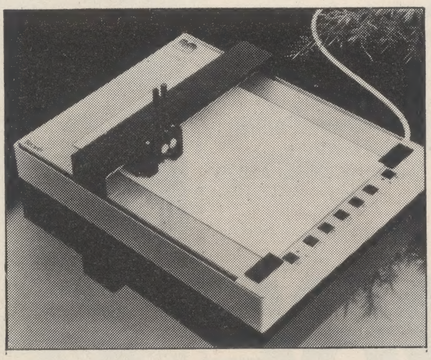
A further very important factor is that Spectravideo have a range of 15 add-on peripherals including RAM expansion cards, floppy disc drive, graphics tablet and printer. All of these are available now from CK Computers, which makes a nice change from other makes.

The SV-318 at £173 complete with data cassette is extremely competitively priced for a personal computer with these features and a memory capability of 32K RAM expandable to 144K RAM and 32K ROM expandable to 96K ROM. The SV-318 also has a joystick built into the keyboard, another unique feature in this price range.

For the professional businessman the model SV-328 (priced at £239 complete with data cassette, 80K of RAM expandable to 256K and 48K ROM expandable to 96K) represents a long term investment which allows memory to grow as the users' requirements increase. Main features include an 87-key keyboard, 80-column display and numeric keypad, and 256 by 192 pixel screen resolution. CK Computers Ltd are at 6 Devonia House, High Street, Worle, Weston-super-Mare, Avon BS22 0JR (telephone 0934 516246). **Computing Today** will shortly be receiving a Spectravideo computer for review. Watch these pages!

DAM CLEVER

Linear Graphics Ltd have announced a £450 plotter for personal computers that employs new linear motor and optical feedback technology to achieve repeatable 0.2mm accuracy over the whole of the plotting area. Known as the Beaver, the plotter is the result of an intensive development and production engineering program at Linear Graphics that has spanned the past year or so.



The Beaver has a Centronics interface as standard (RS232 optional), and can therefore be used with practically any computer. Special software is available, at additional cost, for the BBC models A and B, and Apple II and IIe machines. This software is called 'Interceptor' and has been developed concurrently with the plotter by Linear Graphics.

Interceptor is a powerful routine that intercepts graphic commands for plotting and drawing from BASIC and routes them either to the screen or the plotter as required by the user. As a result, graphics programs already written for the BBC or Apple PCs can run with the Beaver with little or no modification.

The combination of a universal pen holder and a PEN CHANGE command allows most popular 'Roller Ball' or fibre-tipped pens to be used. The PEN CHANGE command causes the pen holder to move to a pen change position on the bed, making it very easy for the user to set the pen at the correct height in the holder.

The Beaver is a flat bed machine with a plotting range of 190 x 272 mm (A4) and will draw on paper, transparencies for overhead projection or even on the backs of envelopes! The paper, or transparency, is held in position by magnetic rubber strips. Accuracy is better than 0.2 mm regardless of the distance moved.

At the right-hand edge of the plotting bed there are a number of switches for manual control of the plotter. These include North, South, East, West, Pen Down, Pen Up, and Line/Local.

The Beaver measures 302 x 381 x 97 mm and weighs in at only 8 kg. Further information can be obtained from Linear Graphics ltd, 34a Brook Road, Rayleigh Weir Industrial Estate, Rayleigh, Essex (telephone 0268 741322).

THE SEEING EYE

A low cost video-camera-to-computer interface aimed at the educational and semi-professional user has recently been launched by Educational Electronics. The interface accepts signals from a variety of sources such as a video camera, VHS player and video disc. It can digitise an image with a resolution of 220 (horizontal) by 312 (vertical) pixels with 64 levels of grey. The unit has wide applications in the fields of art, design, science, robotics and technology.

The low cost of the Video Interface has been made possible by replacing many functions usually performed by hardware with appropriate software. This also greatly

enhances flexibility as the software can enable various parts of the image to be selectively scanned, giving more detail or detecting rapid movement in certain defined areas. Trade-offs can also be made between computer memory size, number of pixels scanned and the number of bits per pixel (representing the intensity) stored in memory. The information can then be displayed on a monitor, saved to disc or processed to extract specific information (such as area and perimeter analysis, shape recognition etc.) In addition the ability to attribute a specific colour to a particular intensity (ie the use of 'false colour') can be used to highlight certain features of the image.

The Interface can be used on virtually any micro with a user port. The unit comes complete with mains power supply, extensive documentation, software support and a connecting lead for the BBC Model B, RML 380/480Z or Apple user port. The cost is £174 (excluding VAT) and further details can be obtained from Educational Electronics, 30 Lake Street, Leighton Buzzard, Beds LU7 8RX (telephone 0525 373666).

MINI-MODEM

Tech-Nel Data Products Limited has launched a low cost ultra-miniature short-range modem, the SRM-6, which costs about one quarter of the price of an equivalent conventional modem and measures just 4.5 x 2.2

x 10.6 centimetres. The SRM-6 is ideal for short haul data transmission, up to 25 kilometres, and needs no AC power supply or batteries. It is therefore extremely suitable for use in large office and factory complexes.

The SRM-6 plugs directly into standard CCITT V-24/RS-232C terminals or computer digital interface connectors. It takes its power from signals emitted by the terminals and from transmit and receive signals, so that no external power source is required. Data is transmitted in full duplex and for wire asynchronous modes over unconditioned telephone lines at any rate up to 19,200 bps.

SRM-6 modems are available by mail order from Tech-Nel in bubble-packed sets of two at prices from £140 per pair, or even less from quantity purchases. Tech-Nel Data Products Ltd are at 8 Haslemere Way, Banbury, Oxon OX16 8TY (telephone 0295 65781).

DON'T WASTE YOUR TIME

Printing out directly from a computer to a printer ties up the computer, often when you most need it. The new compact Microbuffer from Inmac can store up to 64K bytes (or approximately 30-40 pages of A4 text) in its memory as fast as the computer can dump it. This is then fed into the printer at its slower rate, completely freeing the computer to do other operations.

The Microbuffer is compatible with most microcomputers including IBM PC, Apple, TRS-80 and with leading manufacturer's printers such as Epson, NEC, Diablo, C. Itoh and Centronics. It can also be used with most makes of plotters and modems. No modifications are required to the existing software and connection is by standard plugs and cable.

There are two versions of the Microbuffer available which both have a data transfer rate of 4000 cps and cost £225 each (including an AC adaptor). The parallel version comes with a 2 m buffer-to-printer cable. The serial version uses standard RS232 (V24) cable interfaces, has two handshake modes, nine baud rates and a bypass feature for instant printer access.

As with all Inmac products, the Microbuffer comes with a full one year guarantee and is available on a 30 day risk-free trial period and with next day delivery. Full details can be found in Inmac's full colour catalogue which is available free from Inmac (UK) Limited, Davy Road, Astmoor, Runcorn, Cheshire WA7 1QF (telephone: 09285 67551).

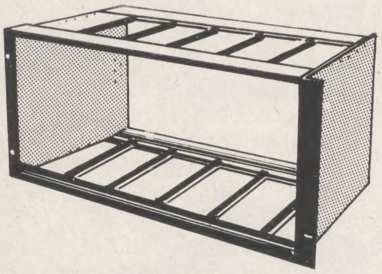
PODS DOWN IN PRICE

Oxford Computer Systems have reduced the price of Interpod — their interface system for the Commodore 64 — to £99.95.

Interpod is an intelligent interface that provides the Commodore 64 with both RS232 and IEEE interface capabilities. Thus users of Commodore's latest home computers are able to take advantage of the wide range of peripherals such as dual disc drives and daisy-wheel printers, and hence extend the capabilities of their system in a low-cost and powerful manner.

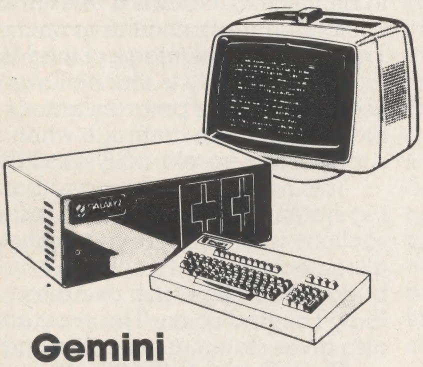
Interpod is available from Oxford Computer Systems, from the UK network of Commodore dealers or from the world-wide network of dealers and distributors for £99.95. For further information please contact Oxford Computer Systems Limited, Hensington Road, Woodstock, Oxford (telephone 0993 812700).

MicroValue - MicroValue



Power Supplies, Mother Boards & Frames

* GM807	3A Power Supply	£40.00
* GM817	6A Switch Mode P.S.U.	£75.00
* GM843	10A Switch Mode P.S.U.	£95.00
* GM656	3 Slot Motherboard	£5.00
* GM654	5 Slot Motherboard	£6.00
* GM655	8 Slot Motherboard	£10.00
* MP840	14 Slot Motherboard	£47.00
* GM662	5 Board Frame	£50.00
* GM610	19" Frame	£37.50



Gemini Galaxy 2

"I would place the Galaxy at the top of my list" (Computing Today, April 1983)

* Twin Z80A Processors
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* 80×25 Video Display
* 64K Dynamic Ram
* Light Pen Interface
* Up to 1.6Mhz Disk Capacity
* Serial RS232 Interface
* Parallel Interface
* Numeric Keypad
* Definable Function Keys
* Cassette Interface
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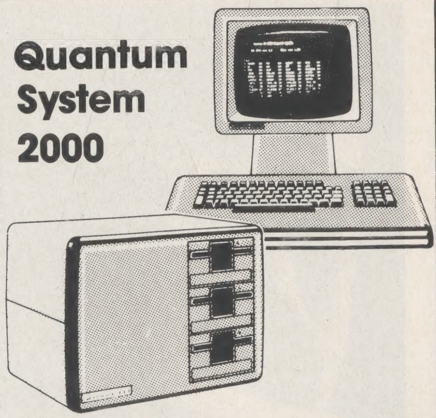
from £1495

Quantum System 2000



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* Up To Three 5.25" Drives
* Fully Expandable
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* CP/M Operating System
* 64K Dynamic Ram
* Definable Function Keys

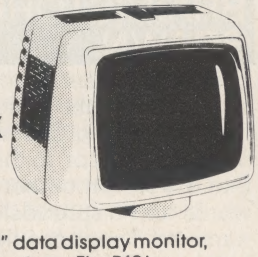
Two-Drive Quantum £1910

Gemini Multinet

The Gemini Multinet enables as many people as possible to have access to their own microcomputer with mass storage and printer facilities for the lowest possible cost. This is achieved by providing a central 'fileserver' fitted with a Winchester hard disk unit and printer interfaces, in conjunction with a method of interconnecting up to thirty-one workstations to the fileserver. The fileserver and each station are fitted with the Gemini GM836 network interface board. A Micropolis 800K floppy disk drive is incorporated in the fileserver providing backup for the hard disk.

GM910 Galaxy 4 Multinet 5.4 M/byte fileserver	£2600
GM912 Galaxy 4 Multinet 10.8 M/byte fileserver	£2850
GM909 Galaxy 4 Multinet workstation	£650

Both fileservers and workstations are supplied complete with VDU's; the operating software is suppliedwith the fileserver.



Phoenix P12 Monitor

A high quality 12" data display monitor, ideal for Gemini systems. The P12 is available in both green and amber phosphor versions and has a resolution of 20Mhz.

£95

BUY FROM THE COMPUTER PROFESSIONALS

MICROVALUE DEALERS:

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Amersham Computer Centre,
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BRISTOL
Target Electronics Ltd., 16 Cherry Lane.
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Electrovalue Ltd.,
28 St. Judes Road, Englefield Green.
Tel: (07843) 3603

LEEDS
Leeds Computer Centre,
55 Wade Lane, Merrion Centre.
Tel: (0532) 458877

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Henry's Radio, 404 Edgware Road.
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LONDON SW11
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Computer House, 58 Battersea Rise,
Clapham Junction.
Tel: 01-223 7730

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SOFT WARES

BRAIN(STORM), NOT BRAWN

This magnificent specimen of humanity is Mike Liardet, and he is the co-author of BrainStorm, an 'ideas processor' in the same way that a word processor processes words and a spreadsheet processes numbers. I suppose that makes him a bit cleverer than the rest of us mortals, but frankly I feel that anyone who volunteers for a photograph like this isn't dealing with a full deck, if you know what I mean. **Computing Today** is, at this very moment, preparing a review of this software package, and I suspect other people may be working a report of Mr. Liardet's mental state.

That whirring noise is Rodin spinning in his grave.

MORE DISCS FROM MOLIMERX

Molimerx are pleased to announce that they have been appointed sole distributors for CP/M 2.2 for the Tandy Model 4 outside the United States. This version from Montezuma Micro is a full CP/M with the original Digital Research utilities, plus a number of others.

Of particular importance is a file which enables this CP/M to interface with 22 other formats of CP/M. Additionally, a utility is included which converts an area of RAM into a pseudo disc drive. Communications and terminal software are also included. The present Tandy owner will be particularly pleased that an extremely easy Format and Backup utility is also included.

This version of CP/M is intended to fill the gap in time pending the issue of the CP/M being written for Tandy by Digital Research. If, when that is released, it is found to be superior to the Montezuma version, then the latter will be discontinued. On the other hand if, as it rather appears at the moment, the Montezuma is superior to the Tandy, then Molimerx will stock both.

Molimerx have also concluded a licensing agreement with Logical Systems Incorporated of Milwaukee, United States, the publishers of LDOS, the disc operating system for the Tandy Model I, Model III and Model 4 machines. This new agreement will enable Molimerx to manufacture in the United Kingdom products to be sold worldwide outside of the continental USA.

The agreement will also enable Molimerx to make a major breakthrough in pricing. Henceforth all LSI products, including LDOS, smalLDOS, The Basic Answer and other well-known packages will be sold in the United Kingdom to the end user at the pound equivalent of the US retail price. In other words, there will be no reflection in the new pricing schedules of Customs duty or shipping.

It is believed that this is the first time in the software industry that the price in the United Kingdom will be the same as that in the USA.

Molimerx Ltd is at 1 Buckhurst Road, Town Hall Square, Bexhill-on-Sea, East Sussex (telephone 0424 220391/223636).

GEMINI GRAPHICS

Henry's of Edgware Road has extended its range of available software packages with the introduction of IVC HI-RES, a program which provides pseudo high resolution graphics on 640 by 250 matrix.

IVC HE-RES has been specially written for the Gemini Multiboard computers, the Gemini Galaxy range, the Quantum 2000, the Kenilworth Personal Computer and CP/M based Nascoms fitted with the Gemini GM 812 IVC. It achieves pseudo high resolution graphics by reprogramming the video control processor and mapping the programmable set generator to the screen.

Available from Henry's at £15 plus VAT, IVC HI-RES provides the following commands: Select mode (48 or 80 column); clear graphics screen; select decimal or binary coordinates; set, reset, invert and test point X, Y; line set, line reset and line invert line X, Y to X1, Y1.

Henry's can be found at 404-406 Edgware Road, London W2 1ED (telephone (01-402 6822).

MICRODRIVE BUDGETTING

With the recent introduction of the ZX Microdrive you now have the ability to load the Cash Controller program and make an entry in around 90 seconds. This upgrades the performance of the 48K Spectrum for more serious roles.

Richard Shepherd Software have just released a professional-style Cash Controller program (believed to be the first) that has a "SAVE-to-ZX Microdrive" option in the main menu. The obvious advantage of this Microdrive capability is that it allows the user to SAVE the program onto a blank Microdrive cartridge when supplies are more readily available.

This home budgeting and banking system handles up to 400 transactions which can be automatically allocated against 16 selected budget headings such as Rates, Gas, Tax and so on. The program also gives statements on demand.

Cash Controller for the 48K Spectrum with ZX Microdrive compatibility costs £9.95 and is now available by mail order, telephone credit card order or from most leading computer stores. Contact Richard Shepherd Software, Elm House, 23-25 Elmshott Lane, Cippenham, Slough, Berks (telephone 06286 63531).

LEARN WITH GRIFFIN

Griffin Software, part of Griffin & George, has launched a new range of educational programs for use on home computers, for young children in the 4-9 age bracket. There are, initially, six programs taking the form of instructional booklets for parents plus computer software tapes attractively packaged and colour-coded.

The new range of Griffin Software children's educational programs is for use initially on two types of home computer — the Sinclair ZX Spectrum 48K and BBC Model B 32K microcomputers — which together constitute some 60% of the total UK home computer market. The educational software will, however, be progressively extended to other home computers as appropriate.

Four of the new home computer programs for 4-9 year olds are available from Smiths, Boots and other leading retail outlets now — 'Wordspell' (spelling); 'Getset' (numbers); 'Numberfun' (addition and subtration); 'Tablesums' (multiplication), while the other two programs — 'Fairshare' (division) and 'Wordgames' (more advanced spelling) — will both be in the shops by the end of November.

The six programs, with colour-coded packaging — blue for software for use on the Sinclair ZX Spectrum and green for the BBC Model B microcomputers — are priced at £7.99 for Spectrum and £9.95 for BBC Model B.

ALLIGATA DATA

Flexibase, Alligatacalc and Scribe II are three home/business utilities for the BBC Model B now available from Alligata Software, of Sheffield.

Flexibase is, as the name suggests, a flexible master database. Available on tape and disc, Flexibase enables users to extend the number of records they can hold by selecting the number of fields in each record and then the number of characters in each field. Output is to either screen or printer. All records can be sorted alphabetically on the first field, with a secondary sort on any of the first 10 fields in preferred order. (RRP is £9.95 on tape; £13.95 on disc).

Alligatacalc is a simplified financial/accounting package designed specifically for the BBC to handle the following tasks: cash flow forecasting: budgetary control; estimating; price lists; discount structures; profit and loss accounts; profitability charts; home finance control; shopping lists. The program will automatically calculate any changes in detail input and instantly correct affected totals, which means that constant updating is simple and fast. (RRP is £9.95).

Scribe II is a professional word processor for the BBC Model B, fully compatible with all versions of the operating system and able to be used parallel or serial printer. The program is simple to use but very powerful, and handles up to 600 lines of text (about two A4 sheets). The main features include menu drive; block insert/replace/delete; 80 characters per line display on screen; adjustable column width; save/load files to tape/disc; print as formatted or unformatted text; user-defined key operation for easy use. (RRP is £9.95 on tape; £14.95 on disc).

For more information contact Alligata Software, 178 West Street, Sheffield S1 4ET.

MICROWRITING FOR PETS

Commodore PET users can now communicate with the Microwriter — the portable hand-held wordprocessor with a unique and extremely simple to use keyboard of just six keys. Microcomputer Services, an appointed Microwriting Centre, has developed the software program 'Speakeasy', which allows two-way transfer of text between PETs and Microwriters.

Now PET microcomputer users can transfer text to their data discs for storage, merging of files or for printing out at a convenient moment. Documents can also be retrieved from the PET and entered into the Microwriter's memory for reference, updating or amendment. The Microwriter can also be used in a networked environment. An interface lead, enabling communciation between the PET, which has IEEE connectors, and the Microwriter's in-built RS232 interface is available from Microcomputer Services.

The 'Speakeasy' program is available from Microcomputer Services, priced at £140. It will also be available soon from other Microwriting centres around the UK. Details are available from Osman Ismail or Leslie Bird at MCS, telephone number 01-802 0019, or 01-809 3896.

DATA GENIE FOR SPECTRUM

Following on the launch of Magpie for the Commodore 64, Audiogenic have now announced Data Genie. Data Genie is an easy-to-use database and record retrieval package that allows users of the Sinclair Spectrum to organise their own records in their own unique manner and to recall them under a wide range or parameters.

The package is controlled through the novel method of 'pop-up' menus which are managed by just three keys. The user selects the required option from each menu by raising or lowering a cursor line. Once the cursor is over the required option, a third key automatically pulls in the menu relating to the option, overlaying the new menu on the previous menu. The user is thus able to follow clearly the steps taken in building up the database. As a menu element is selected, Data Genie automatically writes the relevent part of the program.

Data Genie is supplied on cassette for the Sinclair 48K Spectrum at a cost of £9.95 and is available direct from Audiogenic or the nationwide dealer network. Audiogenic are at PO Box 88, Reading, Berks RG1 2SN.

NEXT MONTH

computing today

MARCH ISSUE ON SALE FEBRUARY 10th

POKER

Following the ZX81 version of Backgammon in the September issue, we now offer you BBC Poker. Written for the 32K BBC Micro with any operating system, this game will shuffle the deck, deal and bet with you, and all without the danger of losing your shirt. The only disadvantage is that you cannot read the expression on the computer's face to find out if it's bluffing! User-defined graphics allow your hand to be displayed on-screen as a set of cards, and if you do run into trouble the computer will even advance a loan of £1000. Bring the casino into your own home with the March **Computing Today.**

EASYCODE

There are some difficulties attached to any series of articles that attempt to teach machine code. For a start, there's a different instruction set for each type of microprocessor. Then the type of microprocessor available depends on which computer you have: not all readers will have the same processor to hand.

We've overcome the problems by inventing our own microprocessor! Easycode uses a simulated microprocessor with 100 'memory locations' available, and using this model we can teach the general principles of machine code programming. The simulation will run on any home computer which supports BASIC and a TV display.

ZX SPECTRUM PRINTER INTERFACE

The Sinclair printer is nice and cheap, but the results are nasty and cheap-looking. It would be better to use a good-quality printer but there are a number of problems: the Spectrum has no Centronics interface and it puts out the wrong codes anyway. Next month we'll be publishing a combined hardware and software project to allow printing on a Centronics device: you can use either a simple DIY interface or the ready-built product from Kempston Electronics, and suitable software will be given for both types.

Articles described here are in an advanced state of preparation but circumstances may dictate changes to the final contents.

GENIE UTILITIES

This short piece of software provides a wealth of extra facilities for the Genie owner. USR calls with multiple parameters, a VDU-type command for easy output of ASCII characters to the display, and conversions between various bases — it's all packed into only 334 bytes of machine code. Don't miss the March issue of **Computing Today.**

SCOPE FOR IMPROVEMENT

The Spectrum is capable of some very advanced graphics effects, as evidenced by the latest in commercial software for the machine. Unfortunately it's been necessary to get your hands dirty with machine code if reasonably-paced arcade games are to be attempted. Until now, that is. SCOPE (Simple Compilation of Plain English) is a collection of just 31 commands that allow anyone to design a game and make it run at machine code speeds. We'll be reviewing this piece of software in the March issue.

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Software News

INNOVATIVE
TRS 80-GENIE SOFTWARE

from the professionals

NEWS FLASH!

Molimerx and Logical Systems of Milwaukee, U.S.A., have joined forces to bring their customers a lower costing product and faster and more efficient service.

From January 1984 all LDOS 5.1.× Logical Systems products, together with some of the LDOS (TRSDOS) 6.× products, will be available from Molimerx at the pound equivalent of the U.S. Dollar retail price. In other words, for the first time the considerable range of products of Logical Systems Incorporated will be available to the end user in the United Kingdom at the price at which the American customer can buy it in the U.S.A. All support for these products is being shifted to England, so that as from 1st January, U.K. customers can have the benefit of this important line, exactly as if it had been written and produced over here.

Adjustments for the exchange rate will be made every six months or so. We are starting with the present exchange rate of 1.48. After VAT is added this scheme results in the price schedule (plus P&P) that follows:

Name	Brief Description	Previous Selling Price	Present Selling Price
DISK/DISK	Convert a disk file to another "disk drive"!	£n/a	£ 76.94
FED II 5.1	All purpose disk file editor	£ 27.60	£ 27.60
FILE MANAGER 5.1	Utility for mass manipulation of files	£ 33.40	£ 30.30
FILE MANAGER 6.0	Utility for mass manipulation of files	£ 33.40	£ 30.30
FILTER PACKAGE 1	Filters to enhance LDOS	£ 22.71	£ 22.54
FILTER PACKAGE 2	Filters to enhance LDOS	£ 22.71	£ 22.54
FIX DISK	A collection of patches for LDOS	£ 13.80	£ 7.76
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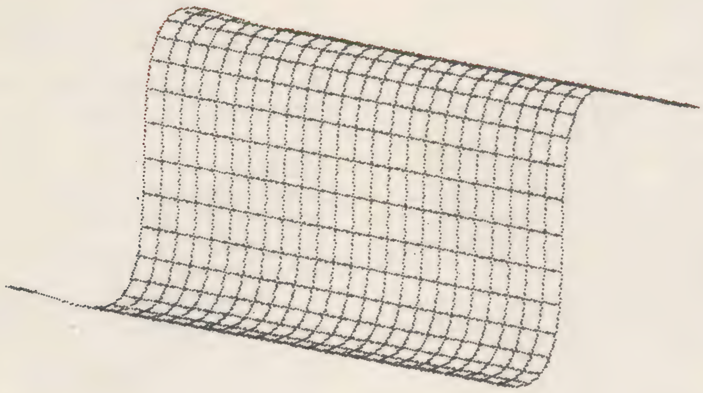
James I. Bartholomew

USING EPSON MX-80 GRAPHICS



The Epson MX-printer is a popular and versatile beast which is capable of a great deal more than just listing your programs. In this article we show you how to make the most of graphics.

When I originally decided to buy a printer it was to help me in the development of programs, to print out results and to use in writing reports and letters. I chose the Epson MX-80 because it was a good, clear typeface and also because it had a dot graphics capability which I thought would compensate for the lack of high resolution graphics on my TRS-80.

When you look at advertising brochures and reviews of printers they usually illustrate the graphics capability by contour maps of some mathematical function and pictures of pretty ladies made up from individual dots. There is very little information, however, either in books or magazines on how to produce these pictures for yourself at home. A digital converter would be required to change a photograph into data for a computer, but mathematical functions can be graphed quite easily.

A favorite function of mine is Z=10★SIN(X)/X, which crops up frequently in science and engineering and has a pleasant appearance. If you wanted to plot this on the VDU you would use a program such as Listing 1 which takes each value of X, calculates the corresponding value of Z, scales the coordinates and displays the point on the screen.

This direct approach cannot be used with the MX-80 as it makes use of the random access characteristic of the VDU; each point can be SET or RESET in any order. With a printer you must start at the top and work down. Once it has advanced to print a lower point, it cannot go back up again.

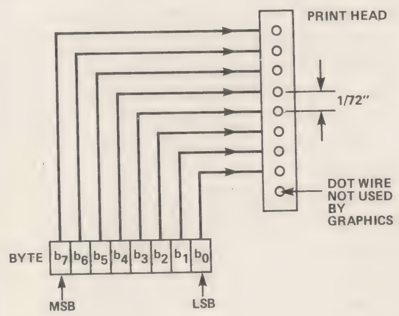


Fig. 1 The association between the data bits and dot wires.

It is necessary, therefore, to calculate each point first, store the results and finally print them. Before we do this, let's remind ourselves of how the MX-80 prints dot graphics.

EPSON GRAPHICS MODE

To enter the normal density bit image mode, the computer must send an ESC K instruction to the printer. ESC is CHR$(27) and K is CHR$(75), sent to the printer as two consecutive bytes, one of 27 and the next of 75.

The next two bytes (n1 and n2) sent to the MX-80 tell it how many bytes (n) of bit image data follow; up to a maximum of 480, the total number of dot positions in a line. These are in order (least significant byte), (most significant byte) and the total number of graphics bytes is given by

```
n = n1 + 256*n2
```

For example, if you want to print 110 bytes of bit image data then n1=110 and n2=0, or to send 310 bytes then n1=54 and n2=1.

Once ESC K n1 n2 has been sent to the printer, the next n bytes will be interpreted as image data and not as characters or printer controls.

Double density graphics are controlled in the same manner by sending ESC L (27 then 76) to the printer, and n1+256★n2 can total up to 960 because dot spacing is halved and there are twice as many in a line.

The print head of the MX-80 contains nine wires one above the other, each capable of printing a single dot. All characters are made up of combinations of these dots. When you enter bit image mode, only the upper eight wires are active, and each bit of a graphics byte controls one wire as shown in Fig. 1.

The most significant bit controls the top wire and the least significant bit the bottom. So, a byte of 255 will fire all eight wires to print eight dots, 15 will print the lower four dots and 0 will print none.

PLOTTING THE FUNCTIONS

Let us now look at two methods of plotting the function Z=10★SIN(X)/X. First of all, we can store all the values of Z in an array and then calculate which should be printed on each row. Or, secondly, we can plot each point into a buffer and then dump the buffer out to the printer.

In the first method, for the range of values of X that we want to use we calculate each value of Z and store it in an array Z(X). Then we scan the array for each value of Z, starting at the highest, and print a dot at the appropriate X position. This is done by Listing 2 and the result is shown in Fig. 2.

If we decide to calculate for values of X between −15 and 15 in

```
99  REM ** Clear the screen **
100 CLS
109 REM ** Calculate function **
110 FOR X=-15 TO 15 STEP .25
120     IF X=0 THEN Z=10: GOTO 140
130     Z=10*SIN(X)/X
139     REM ** Scale coordinates for display **
140     XD=4*X+64
150     ZD=36-3*Z
159     REM ** Display point **
160     SET(XD,ZD)
170 NEXT X
179 REM ** Preserve display **
180 GOTO 180
```

Listing 1. Program to display Z = 10★SIN(X)/X on the VDU.

Fig. 2 A two-dimensional function, Z= 10★SIN(X)/X.

steps of 0.1 there will be 301 values of Z, so we dimension the array. The upper limit of 15.05 in the FOR statement is to compensate for inaccuracies in the single precision maths of the TRS-80. If it starts at −15 and adds 0.1 for 300 times, instead of reaching 15, it gives just over 15 and the loop would finish without calculating that point unless we make the upper limit just over 15.

Line 200 uses ESC A 8 to set the paper advance at a linefeed to 8/72nds inch. As each dot is 1/72nd inch apart this means there will be no spaces between lines. The vertical spacing of dots will be even.

The value of Z will lie between 10 and −3, and for each value we start a new line, set a tab to centre the picture and set the graphics mode.

If the value of Z(N) is less than V then we don't want to plot it yet, so A is set to zero. If Z(N) is not less than V then we have a point that we wish to plot and we must calculate which of the eight dot wires to fire.

As we only wish to plot a single dot, the value to send to the printer will be 1, 2, 4, 8, 16, 32, 64 and 128, which are all powers of 2 ie 2^0, 2^1, ... 2^7. If we subtract the integer part of Z(N) from Z(N) we are left with the remainder RZ, which will be a positive number less than 1. This is multiplied by 8 and the integer taken to give a whole number between 0 and 7 proportional to RZ. This is the exponent EX of 2 we need to print the correct dot. Z(N) is made equal to −100 so it will play no further part.

A peculiarity of the TRS-80 is that it will not LPRINT CHR$(0), (10), (11) or (12); if any of these values might be used we have to POKE the value to the printer which is located at memory byte 14312. The MX-80 puts a 63 on address 14312 when it is ready to accept data which explains line 300. If your computer can LPRINT any number then replace lines 300 and 310 with:

```
300 LPRINT CHR$(A)
```

You can experiment by substituting your own equations in line 140, using an error trap in line 130 if required. You should have a good idea of the upper and lower limits on the value of Z(N) so you can set the loop in line 210.

Alternatively you can have the program detect these for you by adding the lines:

```
105 ZL=50000: ZH=-ZL
143 IF Z(N)<ZL THEN ZL=Z(N)
146 IF Z(N)>ZH THEN ZH=Z(N)
210 FOR V=INT(ZH) TO INT(ZL)
    STEP -1
```

Good equations to try are

```
Z(N) = 3*SIN(X) + 3*COS(2*X)
Z(N) = 1/2*(X/4)^3 - X
```

BUFFERED PRINTING

The second method we will look at is analogous to printing on a memory-mapped VDU screen. We select a block of memory as a buffer in which we will plot all the points to be printed and then dump the buffer out to the printer.

For example, if we wish to plot Z=10★SIN(X)/X as before with X varying from −15 to +15 in steps of 0.1 and Z between −3 and +10, then we need a buffer 301 bytes wide and 14 bytes high: see Fig. 3. So a continuous block of 4212 bytes must be selected and protected. For a TRS-80 with 16K RAM, plenty of memory can be protected by answering the MEM SIZE? question at switch on with 20000. Whatever your system, choose a suitable value for the start byte SB.

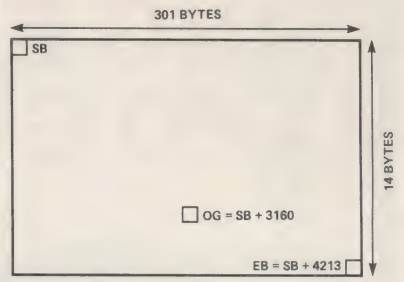


Fig. 3 The print buffer for a two-dimensional function.

SB represents X−15 and Z=10, so the point for X=0, Z=0 is SB+150 (to make X zero) +3010 (to make Z zero. Thus the origin is OG=SB+3160. The end byte EB is SB+4213.

Listing 3 shows the program for plotting the function. Notice the similarities in structure between this program and Listing 1, where the function was plotted on the VDU.

The buffer area must first be cleared to avoid printing random points, then each point is calculated and plotted in the buffer. As before, the appropriate bit is derived by raising 2 to an exponent formed from the remainder of Z.

When plotting the point, the integer part of Z is multiplied by 301, the number of bytes in a line, in order to plot the point in the correct line. Because the top line to be printed is from the lowest memory addresses in the buffer, Z is subtracted from the origin rather than added.

When dumping the buffer, C is used to count the number of bytes printed in a line and when it reaches 301 a linefeed is sent, followed by data to set up the bit image mode for

```
99  REM ** Dimension array **
100 DIM Z(301)
109 REM ** Calculate function **
110 FOR X=-15 TO 15.05 STEP .1
120    N=INT(X*10)+151
130    IF X=0 THEN Z(N)=10: GOTO 150
140    Z(N)=10*SIN(X)/X
150 NEXT X
199 REM ** Set line spacing **
200 LPRINT CHR$(27);CHR$(65);CHR$(8)
210 FOR V=10 TO -3 STEP -1
219    REM ** Prepare graphics mode **
220    LPRINT TAB(15);CHR$(27);CHR$(75);CHR$(45);CHR$(1);
230    FOR N=1 TO 301
240       IF Z(N)<V THEN A=0: GOTO 300
250       RZ=Z(N)-INT(Z(N))
260       EX=INT(8*RZ)
270       A=2[EX
280       Z(N)=-100
299       REM ** Print point **
300       IF PEEK(14312)<>63 THEN 300
310       POKE 14312,A
320    NEXT N
330    LPRINT
340 NEXT V
349 REM ** Reset printer **
350 LPRINT CHR$(27);CHR$(64)
```

Listing 2. Progam to store a function in an array before printing.

```
99  REM ** Select buffer address **
100 SB=20000: OG=SB+3160: EB=SB+4213
109 REM ** Clear the buffer **
110 FOR B=SB TO EB
120    POKE B,0
130 NEXT B
139 REM ** Calculate function **
140 FOR X=-15 TO 15.05 STEP .1
150    IF X=0 THEN Z=10: GOTO 170
160    Z=10*SIN(X)/X
169    REM ** Scale coordinates for plotting **
170    XD=INT(10*X)
180    ZD=INT(Z)
190    RZ=Z-ZD: EX=INT(8*RZ): A=2[EX
199    REM ** Plot point **
200    POKE OG+XD-301*ZD,A
210 NEXT X
219 REM ** Set line spacing **
220 LPRINT CHR$(27);CHR$(65);CHR$(8)
229 REM ** Set counter **
230 C=301
240 FOR B=SB TO EB
250    IF C<>301 THEN 270
260    LPRINT CHR$(13);TAB(15);CHR$(27);CHR$(75);CHR$(45);CHR$(1);: C=0
269    REM ** Print point **
270    IF PEEK(14312)<>63 THEN 270
280    POKE 14312,PEEK(B)
290    C=C+1
300 NEXT B
309 REM ** Reset printer **
310 LPRINT CHR$(27);CHR$(64)
```

Listing 3. Program to store a function in a buffer before printing.

```
99  REM ** Select buffer address **
100 SB=20000: OG=SB+6308: EB=SB+12616
109 REM ** Clear the buffer **
110 FOR B=SB TO EB: POKE B,0: NEXT B
119 REM ** Calculate the function **
130 FOR Y=15 TO -15 STEP -1
140    PRINT Y
160    FOR X=-15 TO 15.05 STEP .1
170       R=SQR(Y*Y+X*X)
180       IF R=0 THEN Z=10: GOTO 210
190       Z=10*SIN(R)/R
199       REM ** Scale coordinates for plotting **
210       ZD=Y+Z: IZ=INT(ZD)
220       RZ=ZD-IZ: EX=INT(8*RZ): A=2[EX
230       XD=INT(10*X): YD=-341*IZ
240       B=OG+XD+YD
249       REM ** Check point is in bounds **
250       IF B>EB THEN GOTO 310
260       IF B<SB THEN B=OG+XD-6138: A=0
269       REM ** Erase hidden lines **
270       FOR M=OG+XD+6138 TO B+341 STEP -341
280          POKE M,0
290       NEXT M
299       REM ** Plot point **
300       POKE B,(PEEK(B) OR A) AND (256-A)
310    NEXT X
330 NEXT Y
399 REM ** Set line spacing and counter **
400 LPRINT CHR$(27);CHR$(65);CHR$(8): C=341
409 REM ** Print out buffer **
410 FOR B=SB TO EB
420    IF C<>341 THEN 440
430    LPRINT CHR$(13);TAB(11);CHR$(27);CHR$(75);CHR$(85);CHR$(1);: C=0
439    REM ** Print point **
440    IF PEEK(14312)<>63 THEN 440
450    POKE 14312,PEEK(B)
460    C=C+1
470 NEXT B
479 REM ** Reset printer **
480 LPRINT CHR$(27);CHR$(64)
```

Listing 4. Program to print a three-dimensional function.

```
99  REM ** Select buffer address **
100 SB=20000: OG=SB+6308: EB=SB+12616
109 REM ** Clear the buffer **
110 FOR B=SB TO EB: POKE B,0: NEXT B
119 REM ** Calculate the function **
120 C=10
130 FOR Y=12 TO -12.05 STEP -.1
140    IF C=10 THEN S=.1: C=0: PRINT Y: GOTO 160
150    S=1
160    FOR X=-12 TO 12.05 STEP S
170       R=SQR(Y*Y+X*X)
180       IF R=0 THEN Z=10: GOTO 200
190       Z=10*SIN(R)/R
199       REM ** Scale coordinates for plotting **
200       X1=(X+Y)*.7071: Y1=(Y-X)*.7071
210       ZD=Y1+Z: IZ=INT(ZD)
220       RZ=ZD-IZ: EX=INT(8*RZ): A=2[EX
230       XD=INT(10*X1): YD=-341*IZ
240       B=OG+XD+YD
249       REM ** Check point is in bounds **
250       IF B>EB THEN GOTO 310
260       IF B<SB THEN B=OG+XD-6138: A=0
269       REM ** Erase hidden lines **
270       FOR M=OG+XD+6138 TO B+341 STEP -341
280          POKE M,0
290       NEXT M
299       REM ** Plot point **
300       POKE B,(PEEK(B) OR A) AND (256-A)
310    NEXT X
320    C=C+1
330 NEXT Y
399 REM ** Set line spacing and counter **
400 LPRINT CHR$(27);CHR$(65);CHR$(8): C=341
409 REM ** Print out buffer **
410 FOR B=SB TO EB
420    IF C<>341 THEN 440
430    LPRINT CHR$(13);TAB(11);CHR$(27);CHR$(75);CHR$(85);CHR$(1);: C=0
439    REM ** Print point **
440    IF PEEK(14312)<>63 THEN 440
450    POKE 14312,PEEK(B)
460    C=C+1
470 NEXT B
479 REM ** Reset printer **
480 LPRINT CHR$(27);CHR$(64)
```

Listing 5. Program to print an oblique view of a three-dimensional function.

the next line: C is then reset to zero. It is set to 301 initially in order to print the first line.

If we compare the two methods we see that the first calculates the values of Z quite quickly, although it is a bit slow at plotting the function. The second method uses more memory which has to be protected, takes time to clear the buffer and calculate each point, but is faster at printing out. Both ways are comparable, but the second method of plotting points in a buffer before dumping it to the printer is more versatile, as we shall see when we try to plot three-dimensional functions.

3D FUNCTIONS

Let's look at the plotting of 3-dimensional functions. In these cases we will plot Z as a function of X and Y, or maybe R where R is the distance from the origin. We will plot values of Y above each other to generate the impression of depth.

We will require a larger buffer for these functions, so we will set one which will be used for the remainder of the article. The buffer will be 341 bytes wide by 37 bytes deep, and on my system occupies memory locations 20000 to 32616: see Fig. 4.

When we come to use oblique views, this window will allow plotting of functions with X and Y both varying from −12 to +12. Once again, select a suitable value of SB for your system.

The simplest way to proceed is to select successive values of Y starting in the background and working towards the foreground. For each value Y, a line is plotted by calculating the function Z. Each point is plotted in the buffer as it is calculated.

By starting at the back we can cater for the case of hidden lines, ie lines which will be covered by plotting the function nearer the front. This is done by calculating where a point is to be plotted and erasing any previously plotted points which lie below it.

We are now working in three dimensions so Z can be a function of X and Y or, if it is circularly symmetrical, a function of R, the distance from the origin. In this case, using Pythagoras's theorem, R=SQR(X★X+Y★Y).

As an advance from the function we plotted in two dimensions, let's look at plotting Z=10★SIN(R)/R. The program to do this is in Listing 4 and the result in Fig. 5.

First the buffer is defined and then cleared. Following this are a pair of nested loops to calculate all the points for each value of Y and X. There are 31 values of Y from −15 to 15 and 301 values of X by going in steps of 0.1. So in total there are 9331 points to plot. This takes about an hour to complete, so to keep track of progress and to satisfy yourself the computer hasn't hung up the PRINT Y statement at line 140 is included.

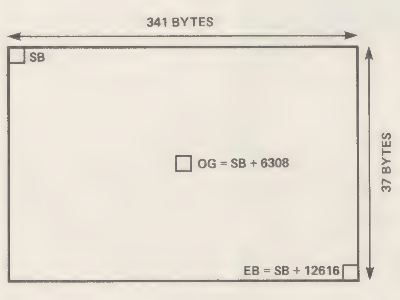


Fig. 4 The print buffer for three-dimensional functions.

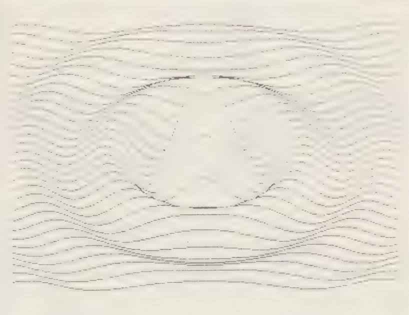


Fig. 5 A three-dimensional function, Z = 10★SIN(R)/R.

This is probably a good place to point out that the listings in this article have been written for ease of understanding and to indicate the structure of the program. Significant savings can be made if spaces and remarks are deleted, multi-statement lines are used and series of calculations are combined, especially within the inner loop.

As an example, line 170 calculates Y★Y 301 times for each value of Y. If this is calculated once as Y2=Y★Y in line 140 then R=SQR(Y2+X★X) can be used in line 170. Another saving could be to convert line 220 to A=2^(INT(8★(ZD−IZ))).

In a manner similar to the two-

dimensional case, the value of Z is calculated, the point to plot is derived and stored in A and the byte in which the point is located is calculated by adding an X and Y displacement to the origin. This takes place in lines 170 to 240.

Lines 250 and 260 then check if the byte is within the bounds of the buffer. If it is after the end byte EB the point is ignored. If it is before SB then the point is not plotted but it will be in front of any points already plotted below it in the buffer. In this case the byte is converted to the top row of the buffer to enable hidden line removal and A is reset to 0 so no point will be plotted.

Hidden lines will be erased by the routine in lines 270 to 290. As we plot the function from the back forward, any previously plotted point will be behind the point currently being plotted. If it is also below the current point then it is 'hidden' and must be erased. The routine starts at the bottom of the buffer and resets to zero all bytes directly below the byte in which the point is to be plotted.

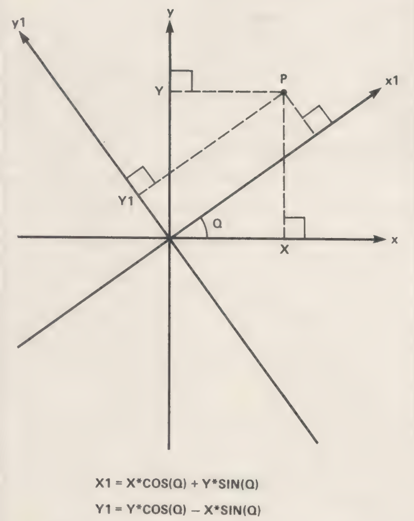


Fig. 6 Relationships for the rotation of axes.

There is still a problem of hidden points within the byte as each bit represents a separately plottable point. More significant bits than the one in which the point is plotted are not hidden and most be retained, but the less significant bits must be erased. The logical expression in line 300 accomplishes this.

A is a power of 2 and represents one bit. If ORed with PEEK(B) it is equivalent to setting that bit. (PEEK(B) OR A) therefore represents the contents of B with the bit set that we are interested in. For example, if B has two bits set, say the LSB and MSB, and A = 16, then:

```
         PEEK(B) = 1 0 0 0 0 0 0 1
               A = 0 0 0 1 0 0 0 0
(PEEK(B) OR A) = 1 0 0 1 0 0 0 1
```

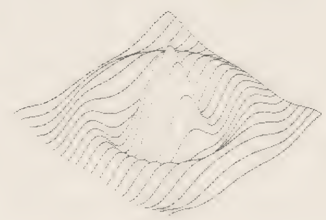


Fig. 7 An oblique view of the function Z = 10★SIN(R)/R.

Remembering that A is a power of two, a little experimenting will show that (256 – A) represents a binary number with all bits above and including A set, and all below A reset.

```
        A = 16 = 0 0 0 1 0 0 0 0
(256 - A) = 240 = 1 1 1 1 0 0 0 0
```

(256 – A) represents a mask which passes the bits we want and blocks the others.

```
(PEEK(B) OR A) AND (256 - A) =
1 0 0 1 0 0 0 0
```

Once all the points have been plotted, the buffer is dumped to the printer as in the two-dimensional case, except that there are now 341 bytes per line.

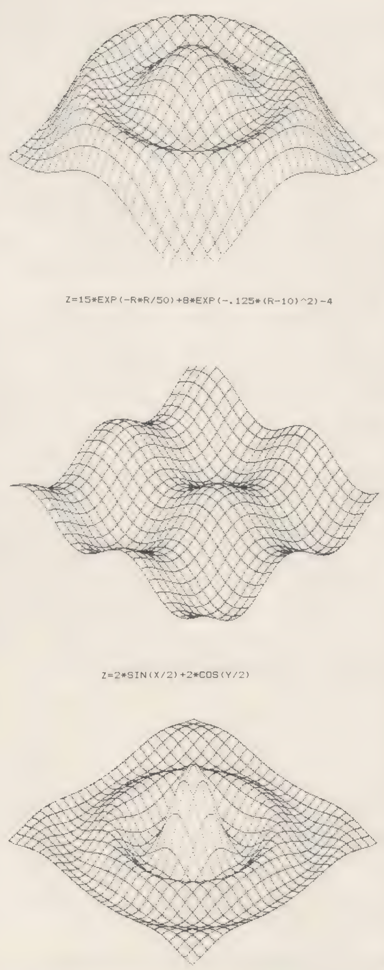


Fig. 8 Some other functions.

OBLIQUE VIEWS

Sometimes it is of value to view a contour obliquely and plot the lines parallel to the X and Y axes. This can be readily achieved with small changes to our program.

First of all, consider how to represent a point viewed obliquely. Suppose we have a point (X,Y) that we wish to view from an angle Q (see Fig. 6). The new coordinates (X1,Y1) are calculated by:

Take in CRA 8

For the special case of 45°:

```
COS(Q) = SIN(Q) = 0.7071
X1 = (X + Y)*0.7071
Y1 = (Y - X)*0.7071
```

To produce Fig. 7 this change is included in Listing 5 at line 200, along with other changes and additions. First of all, X and Y are limited to between +12 and −12 giving a maximum value for X1 of:

```
(12 + 12)*0.7071 = 16.97
```

The minimum value is −16.97 and the same holds for Y1. This uses the whole width and height of the buffer.

For all integer values of Y the value of X is incremented in steps of 0.1, which effectively plots a continuous line parallel to the Y axis. At all other Y values, X is incremented by 1 to build up the lines parallel to the X axis. The value of the step is calculated in lines 140 and 150. C is introduced as a counter to determine when the step of 0.1 is required and is initially set to 10.

With these changes made, the program calculates the function and plots it using X1 and Y1. Plotting the points into the buffer and dumping the buffer to the printer are accomplished in the same way as in the previous listing.

FURTHER DEVELOPMENTS

Considering the time it takes the programs in this article to run, it would be a wise move to write machine language routines to clear the buffer and dump the buffer to the printer. However, by far the longest time is taken in calculating all the points and plotting them in the buffer. A routine to save the buffer to tape or disc could save a lot of time in future if it was necessary to print out a function again.

With a little adaptation these routines could be used to plot functions on the video display if your computer has a high resolution graphics capability. This would give the enjoyment of being able to watch the picture being built up rather than just imagining it.

Don Thomasson

SPECTRUM MACHINE CODE

With a hefty piece of machine code to write on the Spectrum, our reviewer looked around for some tools to help him out. This is what he found.

Facing the task of writing a fairly large machine code program for the Spectrum, I began to cast round for the information and software tools which I would need. The results may be of interest to others who are making similar investigations.

Where information on the contents of the Spectrum ROM is concerned, the obvious authoritarian source is **The Complete Spectrum ROM Disassembly** (Logan & O'Hara, Melbourne House). This gives all the interpreter and operating system details, with terse comments, and all the information one could possibly need is there — somewhere.

Being naturally lazy, not to say slightly pressed for time, I hoped to be able to supplement this data with some more direct information on how the ROM routines could be accessed. A set of three books from Interface was suggested, but these proved a disappointment.

Perhaps I should mention at this point that I have been working in Z80 machine code quite happily for some three years now, having graduated through a number of other processors before that. What I wanted was data relating to the Spectrum. For information on the Z80, it would be difficult to improve on **Programming the Z80** (Rodnay Zaks, Syber), which has long been our standard reference on the subject.

The three Interface books were aimed at comparative beginners, even though one had the subtitle 'For Advanced Programmers'. Starting with explanations of binary and hexadecimal notation, they moved quite briskly forward, but were primarily concerned with machine code as a support to BASIC programs, whereas I needed information on the use of ROM routines to support machine code.

There were also some rather fundamental errors. In the volume subtitled 'For Beginners', it was said that addition could only be performed in the A register, a lengthy explanation being given of a way to perform HL = HL + DE via the A register. The instruction ADD HL, DE would have been more appropriate. It was also stated that the carry flag could not be transferred to the A register, which is nonsense.

These may seem to be very minor points, but such mis-statements have a way of spreading themselves. It seemed most unfortunate, to put it mildly, that beginners should be misled in this way.

It was also a pity that some of the listings were printed as facsimiles of rather tatty ZX Printer output. Now that there are several systems for driving respectable printers from the Spectrum this is unnecessary. One long listing in the largest of the three books was based on the output of a printer which with a very limited character matrix, and that was very difficult to read. However, most of the rest of the book used typeset listings that were very clear.

The first two books were both titled **Spectrum Machine Code Made Easy,** Volume 1 (James Walsh) being subtitled 'For Beginners', and Volume 2 (Paul Holmes) being subtitled 'For Advanced Programmers'. Both authors are teenagers, and while their text showed considerable maturity the content perhaps reflected their limited experience.

The third book, titled **Mastering Code on your ZX Spectrum** (Toni Baker), was much more comprehensive, giving some quite substantial programs as illustrations.

These three books were examined in detail, but several more were examined before it became obvious that there was a distinct gap in coverage, with nothing to provide the data needed by the relatively serious programmer. This is rather typical of the personal computer scene. There is plenty of help for novices, up to a point, but thereafter they are left to their own devices. But for that, many more would be able to continue their development to higher levels.

The next need was for software tools. For programs up to around 600 bytes, I will happily code by hand, but with 6000 bytes and a large database in prospect an assembler was obviously desirable.

The first specimen, the Zeus Assembler from Crystal, failed to please. It gave a display in normal Spectrum lettering, lower case, in black on white, and there was little in the way of formatting to make the result readable. For example, labels tended to get buried in a confused mass of text, where they should have been in a column on their own.

The second offering brought relief. The Picturesque Editor/ Assembler was in a different class: the display was a pleasant white on blue, with 40 columns neatly divided into appropriate fields. Capital letters of very readable form were the norm, though lower case became available for text between quotes, used for comments and messages, The Editor provided auto-numbering and renumber, making insertions as easy as in BASIC, and the simple command set provided all the functions needed.

There was the slight snag that the cursor had to be moved to the left-hand column before any command

was recognised, but that soon became a matter of habit. There was also the fact that the all code was assembled in the Object Buffer, starting 256 bytes above STKEND, whatever the stated origin for the code might be. It was then necessary to save the Object Buffer to tape, producing a result that could be loaded into the correct position by the usual LOAD"" CODE command.

Nevertheless, it was possible to test code before saving it by specifying ORG#, which put the origin at the start of the Object Buffer. Once the code was proved, it could be reassembled with the proper origin, and saved to tape.

Verify was intelligent enough to know what kind of recording was involved, either source text or object code, and it was possible to retain the contents of the Lable Table while loading fresh source code.

In short, the system was a near-professional standard in concept, and thoroughly professional in execution, which is more than could be said of some of its competitors.

The program also has the benefit of a good backup service. A mild query brought a full page letter of explanation, together with a copy of the most recent issue of the tape. In response to a question about driving more respectable printers, the letter also enclosed a listing for a driver to match the Kempston interface, and that was the clincher, since it would allow the programs produced to be properly documented on an Epson MX80.

As a companion to the Assembler, Picturesque produce a Monitor, both programs being supplied in 16K and 48K form. It is therefore possible to load both at the same time, which can save a lot of fiddling about, at the expense of a reduction in working space.

The Assembler is so quick, especially with no display or printout, that there was little excuse for patching code directly, but the Monitor had a number of other uses. It would move code bodily from one area to another, or fill an area of RAM with a given byte value. It would insert or delete code, moving higher code appropriately. It would jump to a specified start point. It would set, implement, and clear breakpoints, display register contents and alter them, generate a hex dump, or enter text into memory. There was also a conversion routine between hex and decimal. The MX80 printer driver will work with the Monitor, too.

Equipped with these two Picturesque programs, I feel able to approach the task ahead with greater confidence. When such satisfactory offerings are available, it seems a pity that many users, buying blind by post, may well think that less professional programs are the best available. Being a cynic, I sometimes suspect that products that are advertised strenuously are less satisfactory than those which are not advertised at all. Getting in touch with Picturesque was a little difficult, because they advertise very little . . .

The Complete Spectrum ROM Disassembly, Dr. Ian Logan and Dr. Frank O'Hara, Melbourne House, £9.95.
Programming the Z80, Rodnay Zaks, Sybex, £9.95 from The Computer Bookshop, 30 Lincoln Road, Olton, Birmingham B27 6PA.
Spectrum Machine Code Made Easy Vol 1, James Walsh, Interface, £5.95.
Spectrum Machine Code Made Easy Vol 2, Paul Holmes, Interface, £5.95.
Mastering Machine Code for your Spectrum, Toni Baker, Interface, £9.95.
Spectrum Editor/Assembler, £8.50 including VAT and postage.
Spectrum Monitor, £7.50 including VAT and postage.
Both the above from Picturesque, 6 Corkscrew Hill, West Wickham, Kent BR4 9BB.

Not all home computers stay at home.

The BBC Micro is the ideal family computer–simple to operate, yet fast, powerful, with enormous potential.

But it's nice to know, when you buy one for your home, that the business, educational and scientific worlds agree with your choice.

Here are a few stories to illustrate how the BBC Micro gets out and about. And one to remind you how helpful it can be when it stays at home.

A practical lesson in business admin.

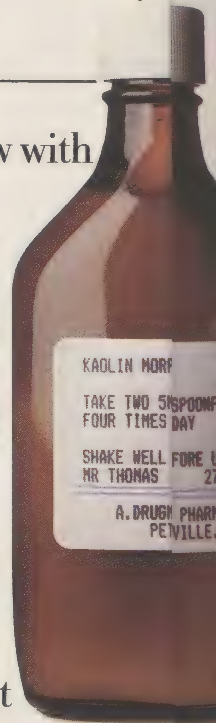
The contribution of the BBC Micro in the classroom has long been recognised at Perins Community School in Hampshire.

The School has 12 BBC Micros used extensively across the syllabus: in fact some pupils are using them to study for their GCE O Levels in computing.

One of the programs available to Perins teachers such as David Beck, pictured below with his class, is "Newsagent."

This program contains all the necessary information for the class to run a newsagent's shop; allowing them to organise daily deliveries, make up bills and keep an eye on stock control and ordering.

It's a nice example of how the BBC Micro can be used not only to acquaint a class with the language of computers, but also with some of the realities of the community in which they live.



Correcting Jodrell Bank.

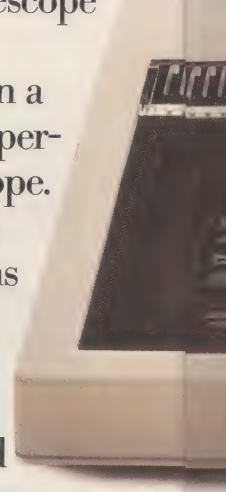
The BBC Micro is a familiar worker around Jodrell Bank.

You'll find it in the reception area explaining the workings of a radio telescope to visitors, for example.

But it's also been helping in a more testing task: to improve the performance of the Defford telescope.

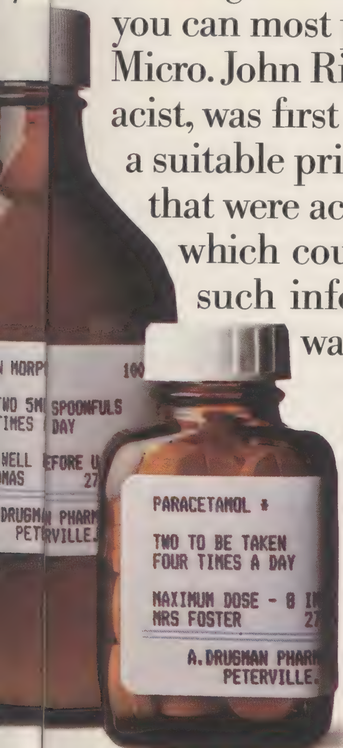
In this application it has been used to make calculations necessary to determine the precise parabolic shape of the dish.

Theodolites are used to do the measuring–then the BBC Micro works out the necessary corrections.



The end of the scrawl.

If any of you have noticed how much easier it is to read and understand labels on drugs and medicines these days, then you can most probably thank the BBC Micro. John Richardson, a Preston pharmacist, was first to realise how a micro with a suitable printer could produce labels that were accurate and legible and which could include, automatically, such information as drug reaction warnings.



At the same time it could record drug usage for better stock control.

He chose the BBC Micro for its versatility and potential for expansion.

John Richardson believes that this system will be recognised as standard in the profession and be used in hospitals, health centres and pharmacies throughout the UK.

Meanwhile back at home.

Dr. & Mrs. Yarwood bought a BBC Micro as a birthday present for their 12 year old daughter.

However, it quite quickly became common property.

All three can now write their own programs. Mrs. Yarwood is particularly proud of one program she has compiled to help teach her daughter French vocabulary.

They all agree that although the Micro is fast and powerful enough to be at home in Jodrell Bank, it is also the ideal computer at the Yarwood home: simple to set up (virtually any TV set and cassette player is all you need) and simple to use.

All this for only £399.

The BBC Micro comes with a comprehensive, step-by-step User Guide which introduces you to your micro and shows you how to construct useful programs of your own.

You will also receive a free "Welcome" cassette which contains 15 different programs for you to experiment with, ranging from music and graphics to games like Kingdom and Bat 'n' Ball.

The BBC Micro is available from W H Smith Computer Shops, Boots, John Lewis and local Acorn stockists.

Alternatively if you would like to order one with your credit card or if you want the address of your nearest supplier just phone 01-200 0200 or 0933-79300.

The BBC Microcomputer System.

Designed, produced and distributed by Acorn Computers Limited.

Tony Cross and Phil Cornes

GETTING MORE FROM THE 64 PART 3

Our final article in this series looks at the sound capabilities of the Commodore 64 (and some of the errors in the User Manual!)

There is no doubt that good sound effects can make even the simplest of games much more exciting to play. But the use of sound in computing need not be restricted to the games applications. Sound, when used properly, can provide as much information as several lines of text. Warning tones, advisory tones, audio feedback on data entry and, on the more advanced machines, real music are all possibilities.

The sound system on the Commodore 64 is well able to provide almost limitless sound effects and excellent music. And because the sound facilities are accessed by POKEing individual registers the system is very flexible. This allows experimentation with all sorts of unlikely combinations of tones and filters when developing sound effects.

THE SOUND SYSTEM ORGANISATION

The sound system is controlled by the Sound Interface Device or SID chip for short. Internally it has three completely separate sound channels or voices. The voices are organised as shown in Fig. 1.

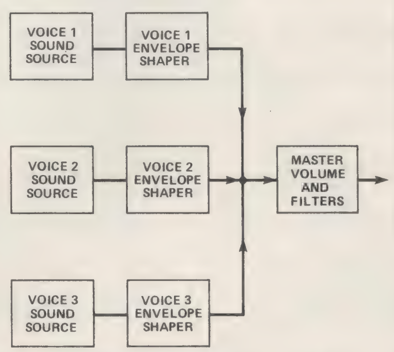


Fig. 1 The organisation of the voices.

Each of the sound sources can produce four different waveforms, triangular, sawtooth, rectangular (pulse) and white noise. The frequencies of each of the waveforms can be individually varied and the pulse width ratio of the rectangular waveform can also be varied. Figure 2 shows the shapes of the four different waveforms. For any particular note, these four waveforms produce very different sounds.

The sound is then fed into an envelope shaper where the Sustain level and the Attack, Decay and Release rates can be set up (the ADSR envelope). Figure 3 shows a typical ADSR envelope. It is this envelope shape which gives musical instruments their distinctive sounds and it is possible to 'simulate' some of them quite well. Alternatively new 'computer instrument' sounds can be produced by using other envelope shapes.

Finally the outputs from the three voices are brought together under a master volume control. Three types of tone filtering can also be introduced at this stage. These are a high pass, a low pass and a band pass filter. The cutoff frequencies of these filters can be individually selected. Figure 4 shows the effects of the three types of filter.

THE SOUND SOURCES

Commodore call the sound sources 'waveform generators' and they have two main functions:

- To produce a note of the selected frequency in the selected waveform.
- To enable the waveform generator output to be turned on or off.

For each voice both these functions are controlled by the same register, the voice control register. These control registers are at the following locations:

Voice 1 = 54276
Voice 2 = 54283*
Voice 3 = 54290

*NOTE — this register is incorrectly specified as 54288 in our version of the User Manual.

The contents of each of the control registers are very similar (we will look at the differences between them later). The bits within the registers are used as follows:

7 White noise select (1 = ON)
6 Pulse waveform select (1 = ON)
5 Sawtooth waveform select (1 = ON)
4 Triangle waveform select (1 = ON)

Bits 1-3 do not concern us here. Leave them at 0.

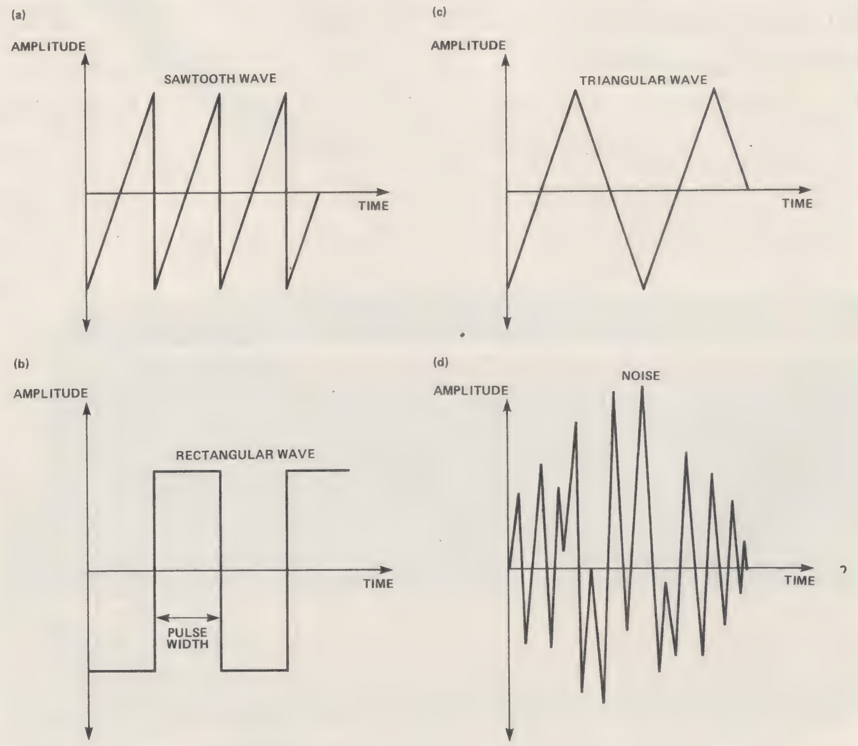


Fig. 2 Four different waveforms. (a) Sawtooth (b) Triangular wave (c) Rectangular wave (d) Noise.

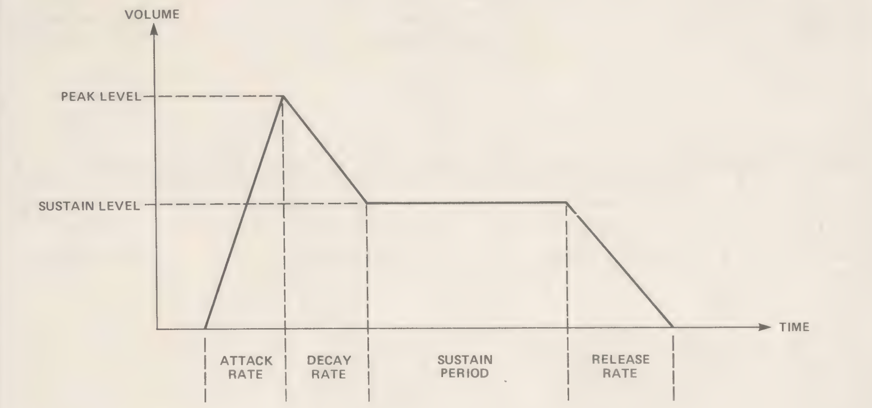


Fig. 3 A typical ADSR envelope.

0 Gate bit (1 = Start attack/decay/sustain cycle).
(0 = Start release cycle)

From this you can see that there are two decimal values for each waveform type: one for the attack/decay/sustain cycle and one for the release cycle. Table 1 shows the two values of each waveform.

The procedure for playing any given note is:

- Start attack/decay/sustain cycle (POKE voice control register, Attack/decay/sustain value).
- Hold sustain for length of note (Count note length).
- When note has finished, start release (POKE voice control register, Release value).

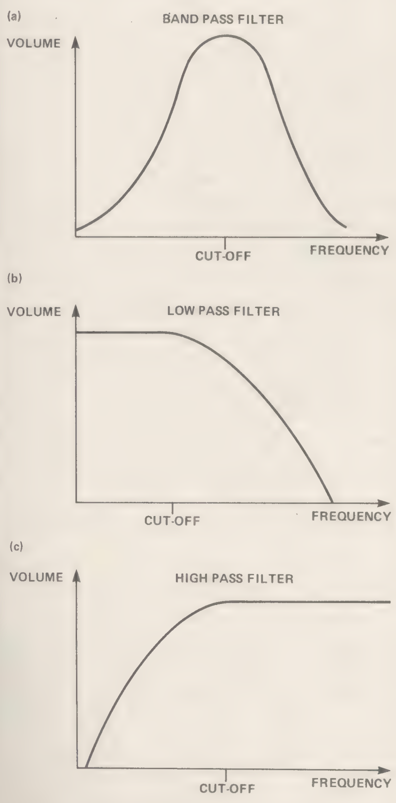


Fig. 4 The effects of various types of filter. (a) Band pass (b) Low pass (c) High pass.

The length of the note depends on the type of note being played (crotchets, quavers and so on all have different lengths). The obvious way to time this delay is with a simple FOR-NEXT loop. You will need to determine by trial and error the delay required for a crotchet to sound the right length, but having found this value all the other note lengths are simply multiples of this value.

PITCHING IT RIGHT

Selecting the frequency of the desired note is a little bit more difficult. For each voice the frequency of the waveform generator output is determined by the values in two registers, the high frequency control register and the low frequency control register. Table 2 shows where the frequency control registers for each voice are located.

The two frequency control registers are 'read' by the SID chip as a single 16-bit register giving 65536 different selectable frequency 'steps'. The waveform generators in the SID chip can generate frequencies in the range 0 to 4000 Hz, so that each selectable frequency step changes the frequency by only 0.06 Hz. Now, we don't believe that anyone can tell the difference between two adjacent steps that are only 0.06 Hz apart!

Within this range of frequencies is a full eight octaves of musical notes. Appendix M in the User Manual lists the high and low frequency values needed to produce 95 of the 96 notes. (More about the 96th note later). These values should not be taken as the gospel truth — indeed a musician would throw up his hands in horror if he saw them! The reason is to do with the way in which the musical scale is constructed. The root note of the scale is usually taken to be A above middle C, which is in octave 4 of appendix M. This note has a frequency of exactly 440 Hz at concert pitch and all computers and synthesizers calculate the other notes from this one such that each note is 2^1/12 (the twelfth root of two) times the previous note. 'Real' notes are not exactly this distance apart but you need a good ear to be able to tell the difference. Table 3 gives a comparison between the Commodore 64 frequencies and 'real note' frequencies for A above middle C and middle C.

The result of all this is that if the values listed in appendix M do not sound right to you then feel free to change them quite drastically. (At 0.06 Hz a step some values may change by quite a lot!)

Finally, when using the rectangular waveform, there is a little bit more work to be done because we also have to set up the pulse width ratio. This value defines how wide the high part of the rectangular wave will be. (See also Fig. 2). Different

Waveform type	Attack/decay/sustain Gate bit = 1	Release Gate bit = 0
Noise	129	128
Pulse	65	64
Sawtooth	33	32
Triangle	17	16

Table 1. Control register values for the various types of waveform.

Voice number	High Pulse Width register	Low Pulse Width register
1	54275	54274
2	54282	54281
3	54289	54288

Table 2. Locations in memory of the frequency control registers.

Note name	Commodore frequency	Real note frequency
A above middle C	440.0 Hz	440.0 Hz
middle C	261.6 Hz	264.0 Hz

Table 3. Frequency comparison table.

values of pulse width can produce an enormous difference in the sound of rectangular waves.

For each voice the pulse width is specified as a 12-bit number, giving 4096 different steps. The high four bits of this number are specified in the High Pulse Width register and the low eight bits are specified in the Low Pulse Width register. Table 4 shows the locations of the high and low pulse width registers for each voice.

The system has been arranged so that a pulse width of 4095 gives an output that is permanently high (maximum width) and a pulse width of 0 is permanently low (minimum width). In both cases the output will be zero. Normally, of course, we will be using values in between these two — typically 2048 which produces a pure square wave.

SCALING THINGS UP

When it comes to actually storing the different notes you clearly don't want to have to store the values for them all, so some means of calculating them is required. The simplest way is to make use of the fact that the notes in one octave are twice the frequency of the notes in the octave below. This means that if we store the high and low frequency values for the highest octave we can calculate all the other octaves by successively dividing by 2.

To do this easily the high and low frequency values must be combined into one 16-bit value. This can be done as follows:-

```
16-bit freq = (high freq)*256 +
              low freq
```

Incidentally, the inverse of this which restores the high and low values from a 16-bit value is:

```
high freq = INT(16-bit freq/256)
low freq = 16-bit freq - high freq
```

If you were to calculate the 16-bit value of the highest octave notes in appendix M of the User Manual you would obtain the values given in Table 5.

The procedure for calculating any note is:
Get the name and octave of the required note.
Read the 16-bit frequency value for the given note from the highest octave values given in Table 4.
IF the octave number is 7
THEN
  Do nothing
  ELSE
  FOR count = 6 TO octave number STEP –1
    Frequency value = frequency value / 2
  NEXT count

Voice number	High frequency control register	Low frequency control register
1	54273	54272
2	54280	54279
3	54287	54286

Table 4. Locations in memory of the high and low pulse width registers.

Note name	High frequency	Low frequency	16-bit frequency
C	137	43	35115
C#	145	83	37203
D	153	247	39415
D#	163	31	41759
E	172	210	44242
F	183	25	46873
F#	193	252	49660
G	205	133	52613
G#	217	189	55741
A	230	176	59056
A#	244	103	62567
B	258	241	66289*

* NOTE — this value is not included in the list in appendix M because it is greater than 65535 and therefore it cannot be 'played' by the SID chip. We have included it for completeness, partly because it is the 96th note and completes the eight octaves, but mainly so that the 'B' note of the lower octaves can be calculated from it.

Table 5. Notes in the highest octave and their 16-bit frequencies.

Recover high and low frequency values from the 16-bit frequency value remaining and POKE these values into the high and low frequency control registers.

SHAPING UP

So far we have obtained a particular note being 'played' in a particular waveform. To make the note sound as though it were coming from, say, a violin or a guitar, we need to adjust its attack, decay and release rates and its sustain level. The effect that each of these parameters has on a note can be seen by referring to Fig. 3.

The Attack rate: This is the rate at which the note rises from zero to peak volume when the gate bit is set to 1.

The Decay rate: This is the rate at which the note falls from its peak volume to its 'average' or sustain level.

The Sustain level: This is the proportion of the peak volume that the decay rate will fall to.

The Release rate: This is the rate at which the note dies away when the gate bit is set to 0, although very often a new note starts before the old note has fully died away.

Each of these parameters can be varied in 16 different steps and since 16 states can be coded into four bits of binary, two parameters can be fitted into one eight-bit register. For each voice, the attack and decay parameters are contained in the Attack/Decay cycle control register and the sustain and release parameters are contained in the Sustain/Release cycle control register. Table 6 shows where the two cycle control registers for each voice are located.

Within the Attack/Decay cycle control registers, the high four bits define the attack rate and the low four bits define the decay rate. Table 7 shows the rates which the different values of attack and decay can select. Within the Sustain/Release cycle control registers the high four bits define the sustain level and the low four bits define the release rate. Table 7 also shows the rates which the different release values can select, and the levels which the different sustain values can select.

Appendix P of the User's Manual gives some sample ADSR settings for 'simulating' some common musical instruments. Personally we're not very impressed by the results, because there's a lot more 'real' sound than just the waveform and envelope shape. We think that it is much more satisfying to create new and different sounds. (After all you could have bought a real instrument for the price you paid for the Commodore 64!).

USING THE FILTERS

You don't have to use the filters at all if you don't need them. In fact, you can produce hours of perfectly acceptable music without ever even thinking about them. The filters are really for 'fine tuning' a sound, to get just the quality you desire. For this reason they probably have more uses in sound effects than in music.

In any case, the sort of filtering you want to do will depend on the waveform you are using. This is because the different waveforms all

Voice number	Attack/Decay cycle control register	Sustain/Release cycle control register
1	54277	54278
2	54284	54285*
3	54291	54292

* NOTE — this register is incorrectly specified at 54286 in our version of the User Manual.

Table 6. Locations in memory of the cycle control registers.

Register value	Attack rate	Decay/Release rate	Sustain level
0	2 mS	6 mS	0 %
1	8 mS	24 mS	6 %
2	16 mS	48 mS	13%
3	24 mS	72 mS	20 %
4	38 mS	114 mS	26 %
5	56 mS	168 mS	33 %
6	68 mS	204 mS	40 %
7	80 mS	240 mS	46 %
8	100 mS	300 mS	53 %
9	250 mS	750 mS	60 %
10	500 mS	1.5 S	66%
11	800 mS	2.4 S	73 %
12	1 S	3 S	80 %
13	3 S	9 S	86 %
14	5 S	15 S	93%
15	8 S	24 S	100 %

Table 7. Control register values and their effects.

have different harmonic structures.

Harmonics are waves produced in addition to the generated or 'fundamental' wave. They are always integer multiples of the fundamental frequency and they have names which reflect this. For example, the second harmonic has a frequency of twice the fundamental, the third harmonic a frequency of three times the fundamental, and so on.

Some waveforms, like the sawtooth waveform, contain all the harmonics, others, like the triangular waveform, contain only the odd harmonics. In addition, the amount of each harmonic present depends upon the waveform. The triangular waveform, for example, contains harmonics in proportion to the reciprocal of the square of the harmonic number: others, like the sawtooth waveform, contain harmonics in proportion to the reciprocal of the harmonic number alone.

When you decide to use the filters it is mainly the harmonics which you will be filtering out because, like the envelope shape, they contain a lot of the 'individuality' of a given sound.

The three filters are actually derived from one programable filter withn the SID chip. This filter can be programmed to act on any combination of the three voices using any combination of the three filter types (high pass, low pass and band pass). The programming is done by using two filter control registers. One, called the Voice Input control register, at location 54295 decimal, selects the voices to be filtered. Table 8 shows which bits select which voices.

The other control register, the Filter Mode control register, at location 54296 decimal, is also the master volume control. Table 9 shows the utilisation of bits within this register.

Having selected the voice and filter combinations we require, all that remains is to set the cut-off frequency for the filter. The cut-off frequency is the frequency at which the filter operates. For example, at the cut-off frequency the low pass filter will start to reject frequencies. As the frequencies increase away from the cut-off the rejection increases. (See also Fig. 4).

The cut-off frequency is specified as an 11-bit number using two registers in a rather strange way. The high eight bits of the cut-off frequency are specified in the high cut-off frequency register at location 54294 decimal. The low three bits are specified in bits 0-2 of the low cut-off frequency register at location 54293 decimal. Bits 3-7 are not used. This gives a total of 2048 different cut-off frequency steps. The SID chip filter can operate over the range 30 to 12000 Hz so that each cut-off frequency step changes the cut-off frequency by about 6 Hz. This should be fine enough control for most applications.

The procedure for using the filters is:

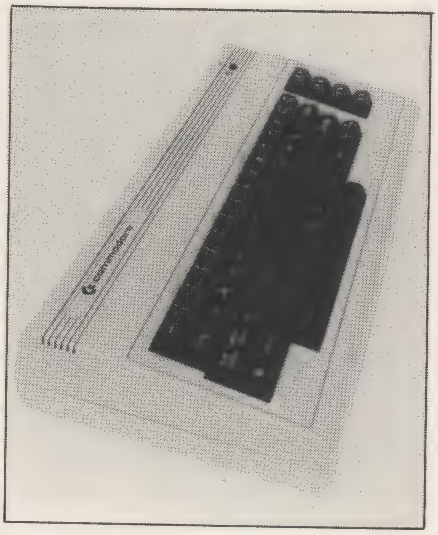
Select the filter type and master volume to be used (POKE 54296, filter type and volume).

Select the cut-off frequency (POKE 54294, high cut-off : POKE 54293, low cut-off).

Select the voices to be filtered (POKE 542295, voice combination).

AND FINALLY

That's all for this month and for this short series on the Commodore 64. We hope that it's been both interesting and useful. And keep watching this space — we'll be back with more Commodore goodies. (Editor permitting of course!).



Bit 0 — Voice 1 filter control (1=Filter, 0=Don't filter)

Bit 1 — Voice 2 filter control (1=Filter, 0=Don't filter)

Bit 2 — Voice 3 filter control (1=Filter, 0=Don't filter)

Bits 3 to 7 — Do not concern us here.

Table 8. Bit functions in the filter voice input control register (located at 54295 decimal).

Bits 0 to 3 — Set master volume (0=Off, 15=Full volume)

Bit 4 — Select low pass filter (1=On)

Bit 5 — Select band pass filter (1=On)

Bit 6 — Select high pass filter (1=On)

Bit 7 — Does not concern us here

Table 9. Bit functions in the filter mode control register (located at 54296 decimal).

CT STANDARDS

Our regular page explaining the meaning of the various symbols we use to make programs portable.

It has been very encouraging to see the number of programs submitted using our standard codes for graphics and other non-printable characters. However, it has also become increasingly clear that some of our readers haven't heard of them and this page is intended to set them out once again.

All standards tend to be irksome to adhere to but the ones laid out here are fairly simple and tend to make software easier to maintain by the programmer and simpler to understand for others.

CONTROL THAT CURSOR

Our original standards have now grown with the times. Machines such as the Commodore VIC which have a dual Shift capability can now be incorporated, as can those systems which use Control key functions.

The recently introduced BBC system offers pre-programmed function keys which, we are glad to say, can also be handled by our original coding system. It's nice to see just how well adapted the original standards have become over the last two years! (Indeed, a whole series of books is using them as its *de-facto* standard.) The standards for the cursor controls are given in Fig. 1.

[CLS]	CLear Screen
[HOM]	HOMe cursor
[CL]	Cursor Left
[CR]	Cursor Right
[CU]	Cursor Up
[CD]	Cursor Down
[REV]	REVerse video on
[OFF]	Turn it OFF
[SPC]	SPaCe
[CTL]	ConTroL key
[fn]	Function key (BBC)
[G<]	Graphic left (VIC/MZ-80A)
[G>]	Graphic right (VIC/MZ-80A)

Fig. 1. Our extended set of cursor control standards includes four new functions.

To indicate more than one of the above, an optional number can be placed within the brackets; [4 CL], etc.

The use of square brackets has raised one or two queries. The reason for this choice is that *most* of the common microcomputer BASICs don't use them for specific functions. In fact, at least one machine provides an added bonus by returning a Syntax Error if they are found, a useful check in case you type them in by mistake.

The code [SPC] was added to the list of cursor control codes to get over the problem of indicating just how many spaces are contained in the gap in the printout. The other common variant of the code for spaces is used by the ZX people. Their choice was ⌴ and this crops up in the various newsletters they publish.

The code [RVS] has caused a few headaches. This is really specific to the PET where the character set can be displayed in reversed video. On machines which don't have this facility you should either find a character in the set which is the reversed image of the one you want and use that or simply ignore it and use anything else you fancy! Don't forget, you may have to look up and alter the values used elsewhere in the program.

THE GRAPHIC SOLUTION

It soon became obvious that the techniques applied to the confusing cursor controls could also be applied to the graphics symbols. The following standard is now in general use in programs published in *Computing Today*.

If a graphics character or characters are to be displayed in a listing (as opposed to POKE codes or CHR$( ) codes) then they are indicated by the method shown in Fig. 2.

Several people have asked what the relationship between the POKE value for a character and that of its shifted graphic might be. In general the shifted version of any character will be 64 greater than the value of that character. This applies to both PET and MZ-80K systems in all cases.

This can be taken further to include machines which use a pixel graphics set rather than pre-programmed PET-style characters and the series of codes for these is given in Fig. 3. As is nearly always the case there is one machine to which the standard shown in Fig. 3 does not apply — Tangerine's Microtan/Micron. This machine uses a four by two cell structure for its pixel graphics instead of the Prestel/Teletext three by two cell. The method for calculating the value to assign to 'P' is shown in Fig. 4, and is fortunately nice and simple.

MAKING REMARKS

Many people scorn the use of REMs within programs but, during the development at least, they are extremely useful. One of the documentation methods that we use is to keep our back-up copy of our programs on a 300 Baud CUTS tape with all the REMs in place: the working copy, be it on tape or disc, is REMless in order to save space.

It is also good programming 'manners' to give your REMs odd line numbers:

```
3999 REM ** CRASH PROOF INPUT
4000 INPUT "THE NUMBER OF ENTRIES ";A
```

A remarkable number of submitted programs have jumps that go not to the relevant point in the program, but to the REM statement. This can cause severe problems when re-numbering after removing the REMs.

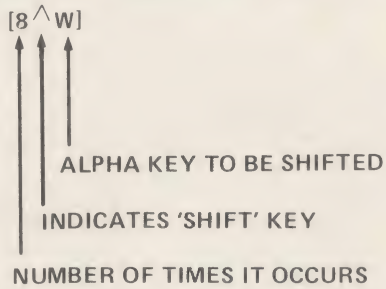


Fig. 2. The way we indicate block graphics on machines like the PET and Sharp. The VIC system of Shift Left and Shift Right is shown in Fig. 1.

1	2
4	8
16	32
64	128

Fig. 4. To convert a Tangerine pixel code into its blocks, simply decode the number into its binary or Hex value and fill in the relevant squares.

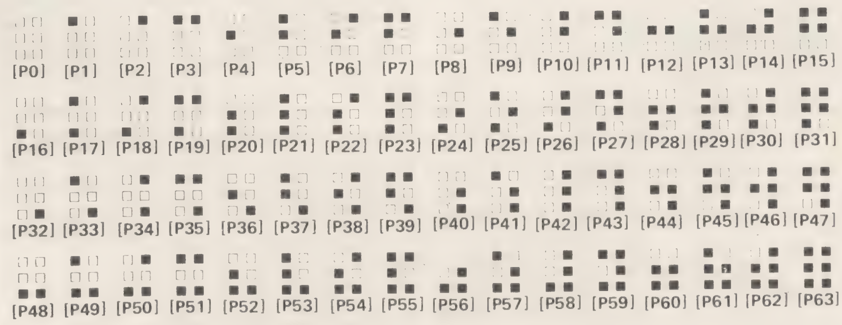


Fig. 3. The standard pixel codes; they will work on most computers which employ this technique as well as for Teletext and Prestel.

Garry Marshall

BOOK PAGE

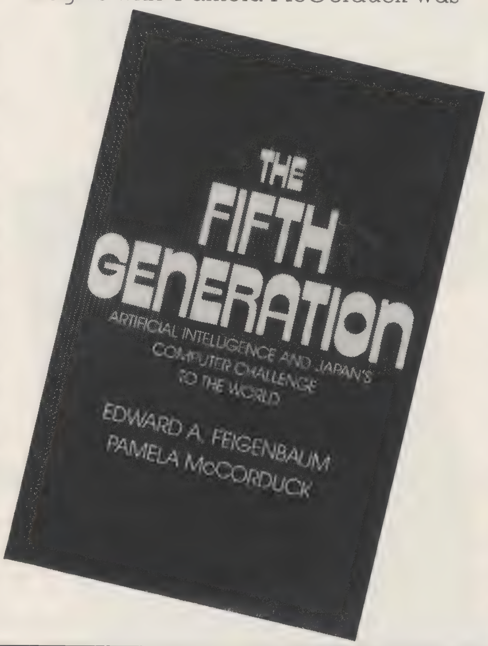
This month our reviewer looks at several books which cover aspects of computing that go beyond simple BASIC programming on your micro.

I reviewed a book on fifth generation computers recently. After spending ages wading through it I wasn't impressed. If only I had waited a bit longer I could have saved myself a lot of time, for this month a book has arrived that gives a splendid explanation of what the fifth generation is all about. It is also probably the most important computer book of the year. Besides this, this month's selection of books includes three books for the BBC Micro that are essentially courses on how to go beyond BASIC with it by using other languages, and one about writing games in Pascal. The sixth and final book brings us neatly in a full circle, because it is about writing expert systems to run on a micro. Expert systems, of course, are at the heart of the fifth generation developments.

The Fifth Generation by Edward A. Feigenbaum and Pamela McCorduck is fundamentally a propaganda job to alert American government and industry to the authors' view that America is losing its lead in computing over Japan at the rate of one day per day as a result of the Japanese national plans for the development of fifth generation computers. This assertion is never really shown to be true, though, and while I don't want to dwell on the politics of fifth generation developments, a couple of remarks may be worth making. There is a fundamental difference between the approaches of the Americans and the Japanese computer companies to research. The American companies are all in intense competition and unlikely to share their findings, while the Japanese companies are collaborating with each other. At the same time a great deal of research is going on in American computer laboratories on the topics that are involved in developing the fifth generation. It has not yet been shown that the Japanese approach is superior to the American. Secondly, the Japanese plans for the fifth generation require that technological breakthroughs be achieved as scheduled activities. This shows clearly the nature of the plans and the degree of risk that is involved. The argument goes that even if the Japanese only achieve a small proportion of their aims they will still achieve an awful lot. But how clear is it that this means they will achieve more than the Americans?

Anyway, to the book. Feigenbaum is Professor of Computer Science at Stanford University and, as head of the Heuristics Programming Project there, is one of the founding fathers of Artificial Intelligence and has established one of the world's major Artificial Intelligence groups. This makes him as well qualified as anybody to assess the fifth generation plans. The first part of the book contains a very readable description of the aims of the fifth generation, of which I shall say no more having devoted a good deal of space to it only recently. In passing, this part of the book demonstrates quite clearly why today's children need to know about computers and computing by showing the extend to which their futures are likely to depend on them. So if anyone still doubts the value of having computers in every school in the country, let them read this book carefully.

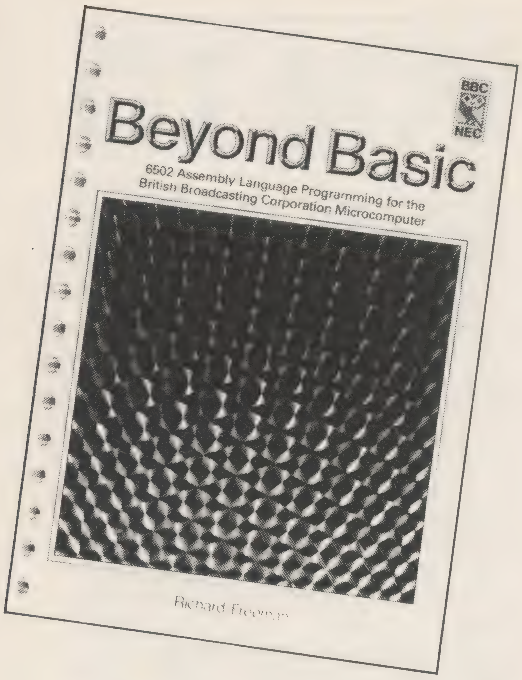
The second author, Pamela McCorduck is a writer on science and I take it to be her influence that has resulted in the most unfortunate style with which some parts of the book are written. To illustrate, Part 2 begins with 'Pamela McCorduck was introduced to the idea of artificial intelligence .... in 1959, by Feigenbaum as it happened, when computing, its natural child called artificial intelligence and certainly they themselves were all much younger'. Although it is a matter of taste, this makes me cringe: it smacks of 'faction' and tends to diminish the credibility of the book. An account of the development of artificial intelligence proceeds in this style and while Feigenbaum obviously belongs in it (self-referentially or not) it is not clear to me what McCorduck is doing there even if she was a spectator.

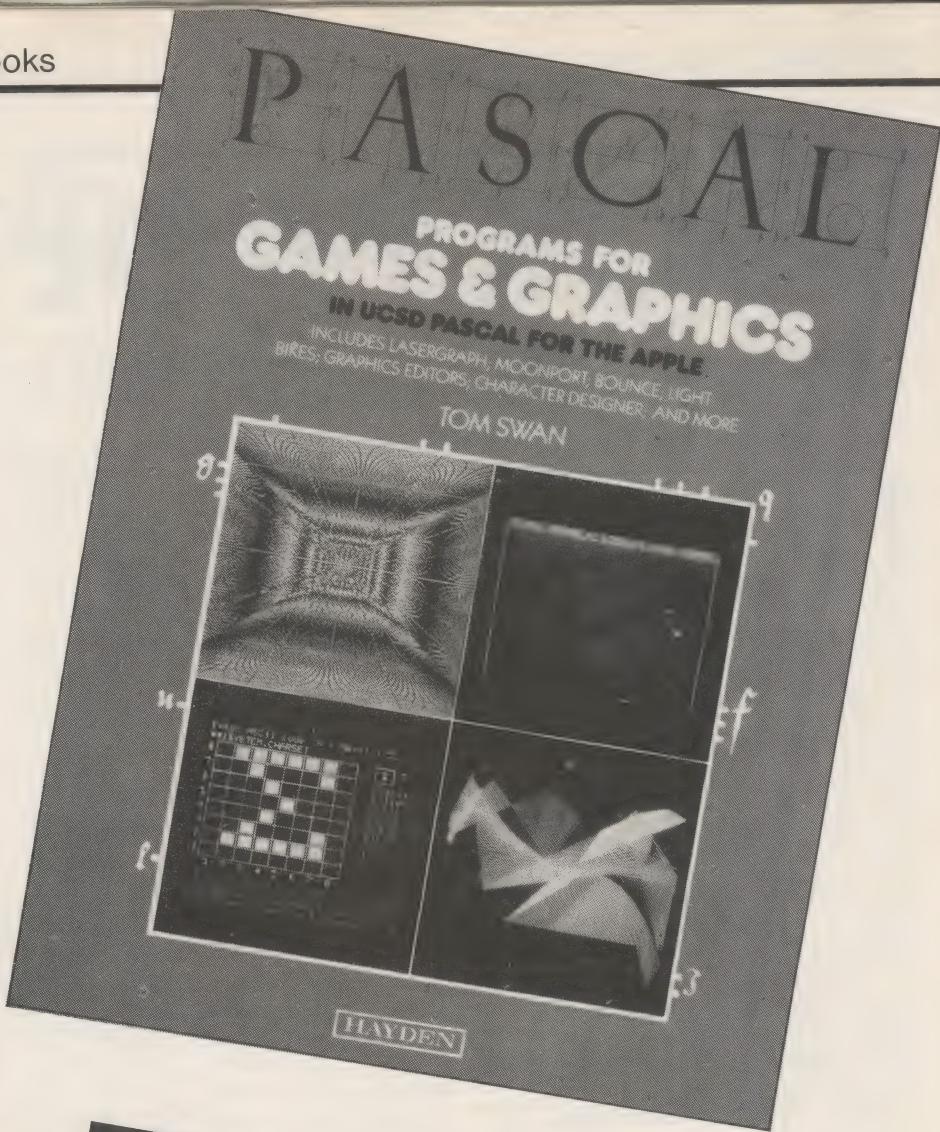


However, if the style of the book is irritating at times, its content is sufficiently fascinating to make up for that. It explains very well that knowledge and information have a value of their own, and unless it is understood that knowledge **is** valuable the whole basis of the fifth generation is inscrutable. That readily available computing power and capability can do so much more than simply store knowledge, and that it can enhance and even create it, is perfectly illustrated by the story of how one of the most influential books on the design of VLSI circuitry, **Introduction to VLSI Systems** by Mead and Conway, was brought to fruition. Its final form, and the short time taken to reach it, both resulted directly from the instant availability of the draft manuscript to many interested parties via the ARPA network. Making the draft manuscript available by this computer communications network allowed many people working in VLSI design to read, test, comment upon and suggest amendments and further material for it. This form of collaboration and opportunity for interaction permitted the book to take a final form, on a very short time scale, which could have been achieved in no other way. Thus, the existence of a computer communications network led directly to the creation of an important body of knowledge.

The book itself is a fine account of all the factors involved in the fifth generation developments. Even with a rather hectoring propagandist approach and its unfortunate style, its contents are never less than fascinating and stimulating.

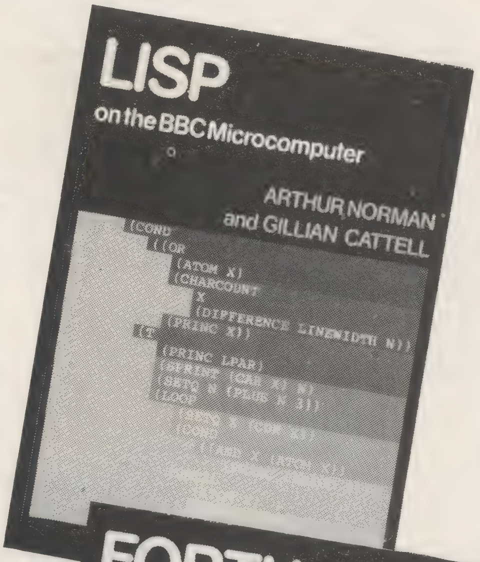
The sub-title of **Beyond Basic** by Richard Freeman is '6502 assembly language programming for the BBC Microcomputer', and this says exactly waht the book is all about. It is a carefully paced course of assembly code programming using the BBC Micro's 'BASIC assembler', with which assembly code segments can be inserted directly into a BASIC program by enclosing them in square brackets. The course covers

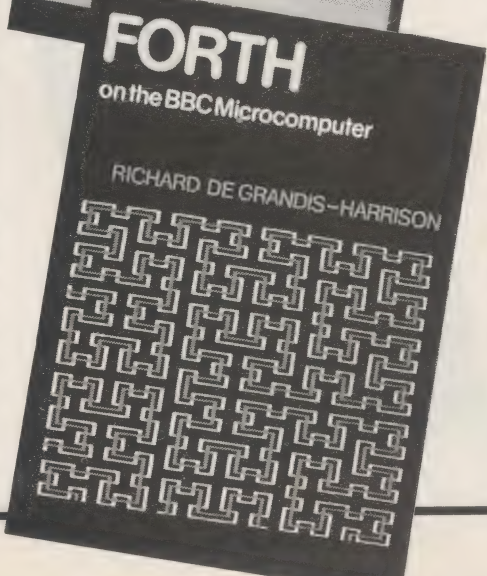




the usual standard material on assembly code programming from simple arithmetic through loops and branches, addressing modes, multiplication and division to the use of the stack, masking and subroutines. It also covers the oddities of the BBC Micro's assembly code programming system, such as how to generate the two-pass assembly process that is necessary, for example, to deal with forward references to labels in assembly code programs. Altogether, the book provides an absolutely standard and solid, though unimaginative, introduction to its subject. It should teach the newcomer to assembly code programming on the BBC Micro everything that is necessary to achieve competence. It is, however, difficult to recommend the book to anyone outside its target audience, as the material on assembly code is covered by many other books in exactly the same form, and the material on the oddities of the BBC Micro is obviously of no interest if you use another computer.

LISP on the BBC Microcomputer by Arthur Norman and Gillian Catell and **FORTH on the BBC Microcomputer** by Richard de Grandis-Harrison are both manuals to accompany Acornsoft's implementations of the respective languages for the BBC Micro. The LISP book is impressive and interesting, but it is my impression that it would be difficult for the newcomer to LISP to progress to the writing of substantial and useful LISP programs with it alone. It presents many examples, but does not spell out the underlying principles of LISP. It also presents a good deal of material that is of no interest to the newcomer to LISP, but which is only of historical interest. It also passes rather quickly from

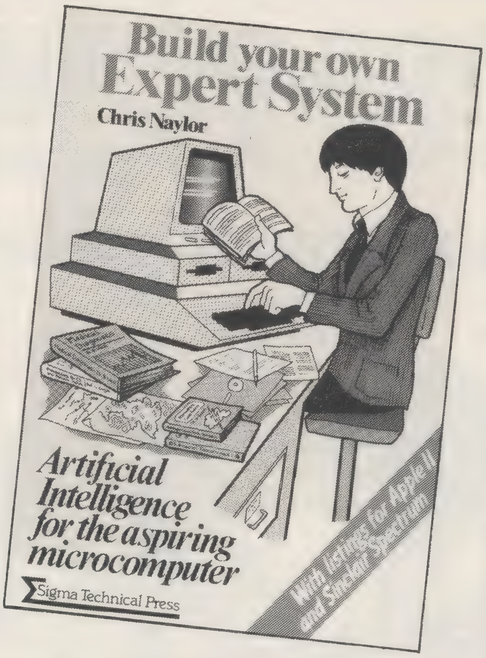




introducing the features of LISP to presenting rather sketchy outlines of medium-sized projects for programming in LISP. Some of the latter are rather imaginative, from a route-finder to an adventure game. Thus, although not well suited to the beginner, it is valuable as a source of reference and as a source of ideas to the fairly experienced LISP programmer with a BBC Micro. This, however, makes the area of interest in the book a rather restricted one.

The FORTH book is also a good, even essential source of reference for FORTH on the BBC Micro. Unfortunately, despite a length of almost 300 pages, it contains few examples programs for applications of any consequence, so that it is short on motivational material which is particularly necessary with a language as unreadable as FORTH. This FORTH book was mentioned by D. S. Peckett in his article 'Going FORTH Again' in the July 1983 issue of **Computing Today** as suffering from production delays. Acornsoft assure us that their production problems have now been solved and that the book, and the language itself, are now readily available. Despite this, I cannot recommend that you rush out and buy it, even if you are a FORTH enthusiast with a BBC Micro, as it is much too stodgy for my taste.

To show that it is possible to write an interesting book on programming in a language other than BASIC for a specific micro, it is only necessary to turn to **Pascal Programs for Games and Graphics in UCSD Pascal for the Apple** by Tom Swan. Here we have a series of programs for imaginative games written in Pascal with a beautifully clean and clear style. Thus, at the same time we have a mine of ideas for games and for graphics (since all the programs make good use of graphics) as well as a practical primer on the writing of well-structured programs. Even if you don't have a Pascal system, the book is worth considering, for the programs are so well written that the task of translating them to BASIC is as easy as it can be. A suite of programs for a graphics editor is also given: that is, for a system to handle graphics in much the same way as a word processor handles text. Converting this for your system could also be a rewarding task. In this way, the book is a good one for its target audience, but it is also of value to others. Can we have more books like this please?



Also, can we have more along the lines of **Build Your Own Expert System** by Chris Naylor? I have to admit that I don't much care for his style of presentation or his sense of humour, and that I would rather not have had to plough through his first two chapters. The first, 'Why expert systems?' takes 12 pages to give the answer 'Because that is what the book is about'. The second, 'A statistical scheme' is a treatment of basic probability theory, not an attractive topic, but even less so when we see Chapter 3 is called 'Avoiding probabilities'! However, I can forgive more than this for the idea behind the book which is to show us how to write our own expert system on our own micro. It includes program listings for the Spectrum and Apple II, and although there is an error in the third line of the very first program, this is fortunately not typical of all the programs in the book. In fact, all the Spectrum programs are reproduced from listings on the Sinclair printer and so can be presumed to be accurate.

The last two books are the kind I, for one, should like to see more of. By demonstrating novel and imaginative ways of programming and using micros, they can only help the progress of the whole micro scene.

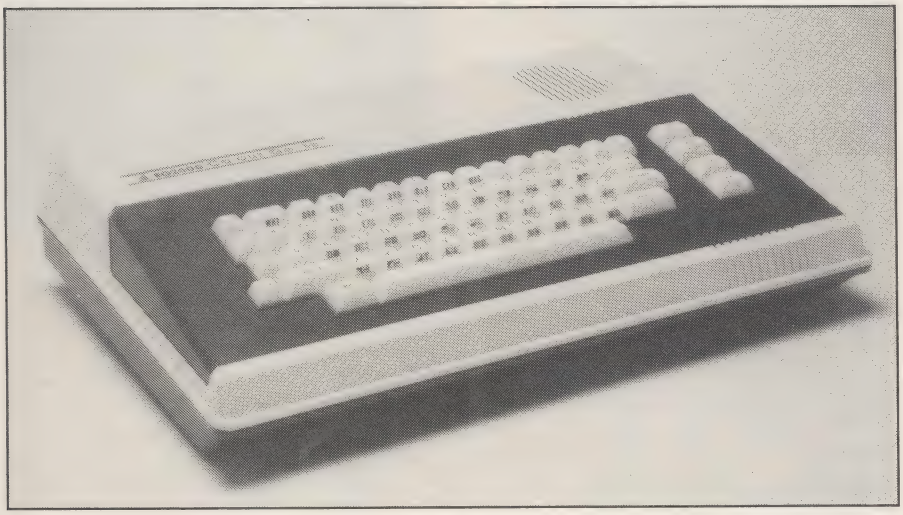
This month's books are:

The Fifth Generation by Edward A. Feigenbaum and Pamela McCorduck, Michael Jospeh, 275 pages, £9.95.
Beyond BASIC by Richard Freeman, BBC and NEC, 256 pages, £7.25.
LISP on the BBC Microcomputer by Arthur Norman and Gillian Cattell, Acornsoft, 197 pages, £7.50.
FORTH on the BBC Microcomputer by Richard de Grandis-Harrison, Acornsoft, 280 pages, £7.50.
Pascal Programs for Games and Graphics by Tom Swan, Hayden, 214 pages, £15.95.
Build Your Own Expert System by Chris Naylor, Sigma Technical Press, 249 pages, £6.95.

John Fairbairn

COLOUR GENIE MONITOR

G-Mon is a comprehensive machine code monitor written for the Colour Genie. Now there's no excuse for not getting to grips with your Z80.



Like many people who learnt Z80 machine language on the Video Genie/TRS 80 system, my first monitor was T-Bug. In my innocence I used this for months, thinking it must be the bee's knees as it was produced by Tandy. As my experience grew I became frustrated with it, and was pleased to see patches in computer magazines for some of the 'bug'-bears I had encountered. Eventually it dawned on me I should get another monitor.

I have been through several now, but none of them seems to give me what I — and I believe most micro users — really need.

Most monitors seem to be digests of systems written for mainframes and minis and we all know that people who work on these machines ***never*** make mistakes. But people like me do type J 5323 instead of J 5332, and our programs do jump to non-existent points and disappear into the wide blue yonder. People like me are always forgetting to fix breakpoints after setting them, and with the constant gnashing of our teeth as we relentlessly type our programs back in after the inevitable crash, we must all be looking more each day like the Laplanders who chew leather for a living.

But I lived lazily with all these problems until recently my Video Genie ground to a halt. This was a marvellous opportunity to upgrade and I didn't have to stop and think what to buy. All the books and tapes I'd bought for the VG couldn't be allowed to go to waste, so it had to be the only compatible machine, the Colour Genie.

Cutting a sob story short, it was nothing like as compatible as I'd been led to believe, at least where machine code is concerned. Conversion is possible, but only if you can get at the machine code — and I couldn't get at that as I couldn't get my monitor in. Before apathy set in and commercial monitors appeared in the shops, I decided to write my own monitor and to get rid of all those niggles I'd had in the past. The result is the program here. It is in BASIC, of course, as that is the only way to get it into the Genie without another monitor, but once it is in you can save it as a SYSTEM tape. It occupies only 770 bytes at the top of memory.

LOADING G-MON

On power-up you should protect high memory for the machine code by answering MEM SIZE? with 30000. Then type the program in and CSAVE it, just in case. Then RUN the BASIC program (it takes about 12 seconds). Nothing visible happens — all that ***is*** happening is that the values READ in by the DATA statements are being put, in hexadecimal form, into high memory in the area from &H7CD0 to &H7FD1.

When the prompt returns you no longer need the BASIC program, except as a back-up. If you have entered the data correctly you should get a checksum of 86325. You should get a cleared screen and a message saying G-Mon 1.1 followed by a prompt, $ in this case. Now you should check all the commands are operating perfectly, so let's run through them.

G-MON COMMANDS

Type **S** and you will return at once to BASIC, with your high memory still protected. To return to G-Mon from BASIC simply CALL 7CD0.

Type **D** (the comuter responds with D:) and then put in a four-figure hexadecimal number (eg 0000 will give the start of the ROM, 7CD0 the start of G-Mon) and as soon as you have typed the fourth digit the comuter will display (or dump) a screenful of memory, neatly formatted for easy checking (128 bytes at a time). Then the prompt $ asks for a new command. This is one of the facilities lacking in T-Bug, by the way (see Photo 1).

Type **R** next and the computer will display the values of the registers (see Photo 2). You obviously have to be familiar with Z80 machine language to make sense of this. Capitals are used for the names of the main register set, lower case for the alternate registers. SP stands for Stack Pointer and BP for Break Point (ie the location of the last entered break point). The values shown are those after the last machine code instruction, which can include some operations caried out by G-Mon on returning from your program. This command is normally meant to be used in conjunction with a break point, in which case it is called automatically and the register values shown are those at the time of the break point with no interference from G-Mon.

Now try **M**. The computer responds with M: and you then have to give it the four-figure hex address at which you want to start putting data into memory. This is the machine-code way of doing what our BASIC program did. G-Mon then repeats the address and shows its current contents. You can then insert data at that point. Each entry must be two hex digits. As soon as you have typed the two digits that value is stored in memory

at that point and the next address is printed. To stop inserting data type **X** at any time and you will return to the prompt $. To move forward or back through memory, without affecting the memory contents, type either ↓ for forward or ↑ for back. In the latter case * will be printed to warn you you are going back (this back-stepping is another feature not found in T-Bug).

Note that the Repeat key will work after all these commands.

You cannot insert data into ROM (if you try it is just ignored) and of course you should avoid putting anything in the area used by G-Mon: 7CD0 to 7FFF (7FD2 to 7FFF is its stack area).

To see M at work, type M:47BF and after the 47BF:20 prompt type 51. You should see Q at the bottom right of the screen (the screen memory occupies 4400 to 47BF). You can also see what you've inserted by running through memory with M or using D for dump.

Try a jump command now: type **J**. This tells the computer to start execution of a program. For the start address you are prompted by J: and you have to insert a four-figure hex address. If you make a mistake you can't backspace. In the case of M and D this doesn't matter, but in the case of J (and T-Bug) the results could be catastrophic if the computer acts on your mistake. Therefore, as a safety measure, once you have put the address in you have to type J again to confirm execution can begin. Typing any other key aborts the instruction and returns you to the prompt $. Then you can try again.

Try J:1A19J and you will return to BASIC (equals the S command). Or you can try J:7CD0J and you will jump to the start of G-Mon, as your screen display will testify. Other jumps have to be controlled, so you must write your program first.

Remember, incidentally, all programs you write should return to a control point when you are debugging them. In this case they could end with a jump back to G-Mon (C3 D0 7C).

BREAKING OUT

Often when you run a program you want to be able to stop it somewhere, typically to check the state of the registers and memory at that point to ensure the programs has no bugs so far. For this you insert, with **B**, a breakpoint (like STOP in BASIC) at the address where you want to stop. This has to be a sensible one — you can't stop in the middle of an instruction — but if you've done it properly, when you run your program (with a J) the program stops as soon as that address is encountered by the program counter.

G-Mon does three things in that case: it prints out the state of the registers at the time of the breakpoint, it returns the user to the prompt $, and it repairs the breakpoint. This means you do not have to press F to fix the break point, as in other monitors. I have also done away with the G (for Go) command as I have never used it. For single-step breakpointing through a program I use another, much larger utility.

Break is one of those instructions that can play havoc with a program if not done right. Therefore when you type B and are prompted with B:, you insert your hex address in the usual way but have to type B again to confirm it (any other key aborts the instruction). You will then be prompted with J: to ensure you do perform the program and clear the breakpoint. You then type in the starting address and J and on return to $ (if your program flow is not faulty and has not avoided the break address) the break point will have cleared.

Note that you can't set a break point in the ROM.

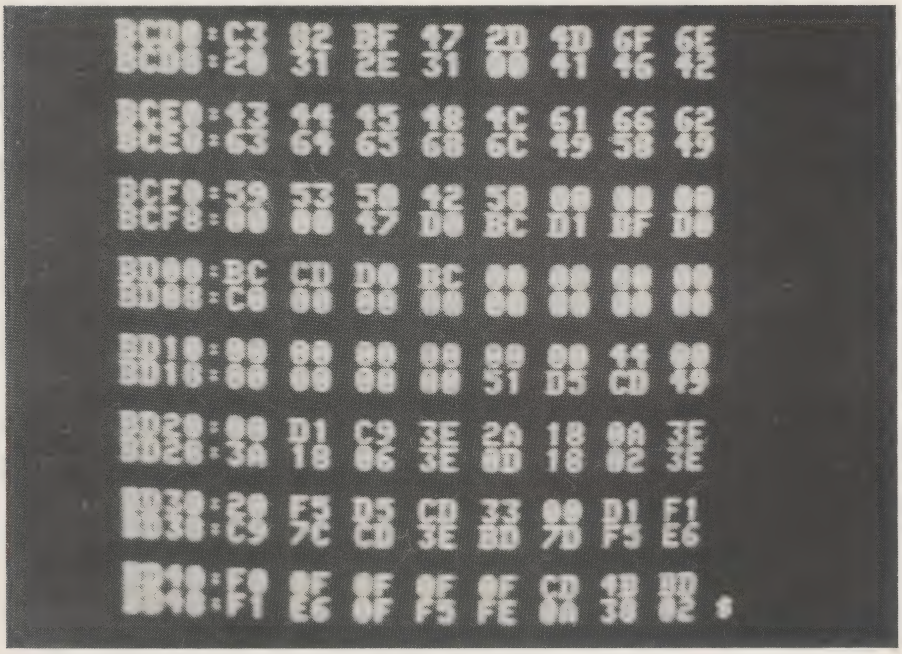
To try this command, first put the following instructions into memory with the M command starting at address 6000: 21 CC 45 3E 51 77 C3 D0 7C. Then type B:6006B and in response to J: type 6000J. You should see a little flash in the middle of the screen and the registers will be printed. The only ones you used were AF and HL and these should read 5100 and 45CC respectively.

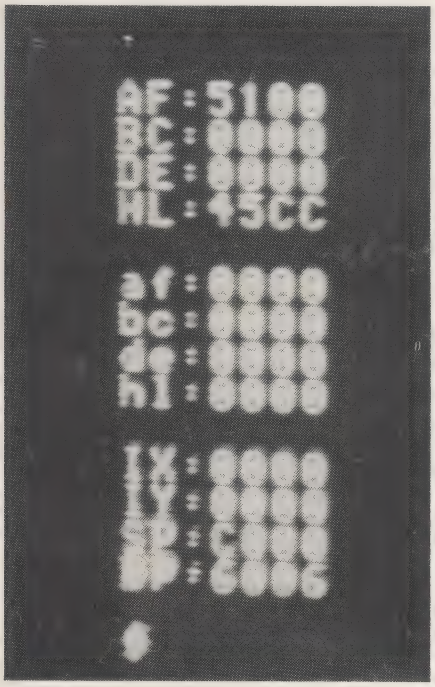
But what was that little flash? One of the things that most intensely annoyed me about my previous monitors was that on return to the prompt they wiped out what was on the screen. If I was debugging a graphics or text display, that wasn't a lot of help. So G-Mon has a Pause command. By hitting **P** you insert a pause just before the machine returns from the break point. To see this in action, type P. An * will be printed as a warning then type in the same break point and jump point as above (6006 and 6000). The * is repeated after the B instruction. On this occasion you should see that in the middle of the screen is a Q. The display will pause there until you hit any key, then you return to $ with the breakpoint *and* the pause cleared.

TAPE STORAGE

If the point you jump from does not pass over the break point you have set you have lost control and can suffer irreversible damage. If you are worried that might happen and don't want to retype your program, the next command is the crucial one. **W** for write writes a SYSTEM tape. After W you will get W:. You now have to insert three addresses in the right order: the starting address of the area you want to copy; then the end address of the area you want to copy (inclusive); then the address at which execution is to begin (this may be in another area).

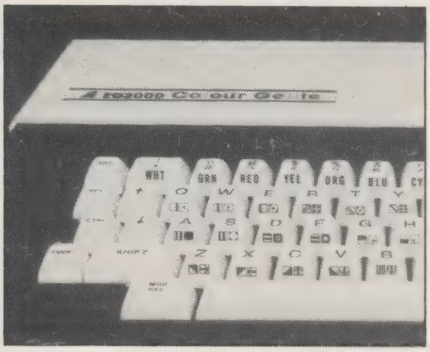
Then you have to give your saved file a name. Since the SYSTEM command reads only the first letter of a name it is pointless giving it a long name, so only one





letter is allowed. Type that letter, which is then displayed. Then a final check — if any of your input is wrong hit any key except W and the instruction will be aborted. If you are happy, switch on your cassette to record and hit W. An ★ will be displayed to warn you recording is taking place. When recording is finished the prompt $ returns (you have to switch off the cassette now).

The first priority is to save G-Mon as a SYSTEM tape. The full instruction for this is W:7CD0 7FD1 7CD0 GW. You will then have created a SYSTEM tape with file name G. To load this, or any other SYSTEM tape, go back to BASIC, type SYSTEM and after the prompt ? type the file name. Switch on the cassette. When the file is found and being loaded, asterisks blink on and off in the usual way. On completion of loading you will be prompted with ? again and can load more programs (it is your responsiblity to see they don't overlap). G-Mon loads in about four seconds.



```
01 02 03 21 D1 7F 11 D1
BF ED B8 06 04 3E 7C 1E
BC 21 D0 BC C5 01 02 03
BE 20 01 73 23 0B 0C 0D
20 F6 04 05 20 F2 C1 3C
1C 10 E6 C3 D0 7C
```

Listing 1. Colour Genie patch.

When all loading is finished answer ? with / then the decimal address of the point you want start execution, or type / alone and execution will start at the address specified for the last loaded tape. At any future point if you RESET, you can get back to your machine-code programs in the same way without re-loading.

If you are already in G-Mon and want to load another tape, you can call the SYSTEM command up from the ROM by means of the instruction J:02B2J.

If you are working with BASIC and G-Mon together, it is your responsibility to set sufficient area free at power-up to allow room for all your machine code programs above BASIC. Those not working in BASIC can use memory from 5800 up. The low-res graphics screen starts at 4400 and the high-resolution display area starts at 4800.

CONVERSIONS

G-Mon is not suitable for other machines because it uses system-dependent code, naturally. But 32K Colour Genie owners can relocate it to the top of 32K memory by loading as above then running the program in listing 1 which should be loaded at 6000, using M. Run it with J:6000 J then, with M, insert the following data at the addresses specified:

BDD9: C0	BE83: 7E
BDF3: C0	BE88: 7E
BD91: 7E	BEAB: 7E
BD9D: 7E	BF2B: 7E
BDAB: 7E	BD3D: 7D
BDFE: 7E	BF4F: 7D
BE1B: 7E	BD39: 7C

You can now save the revised G-Mon on tape with W:BCD0 BFD1 BCD0 GW.

Listing 2. BASIC listing for G-MON.

```
10 FOR I=&H7CDØ TO &H7FD1
11 READ A: POKE I,A
12 T=T+A
13 NEXT
14 PRINT "Data checksum =";T
15 END
16 '
17 DATA 195,13Ø,127,71,45,77,111,11Ø,32,49,46,49,Ø,65,7Ø,
   66,67,68,69,72,76,97,1Ø2,98,99,1ØØ,1Ø1,1Ø4,1Ø8,73,88,73
18 '
19 DATA 89,83,8Ø,66,8Ø,Ø,Ø,Ø,Ø,Ø,71,2Ø8,124,2Ø9,127,Ø,112,
   2Ø5,2Ø8,124,Ø,Ø,Ø,Ø,192,Ø,Ø,Ø,Ø,Ø,Ø,Ø
2Ø '
21 DATA Ø,Ø,Ø,Ø,Ø,Ø,68,Ø,Ø,Ø,Ø,Ø,81,213,2Ø5,73,Ø,2Ø9,2Ø1,
   62,42,24,1Ø,62,58,24,6,62,13,24,2,62
22 '
23 DATA 32,245,213,2Ø5,51,Ø,2Ø9,241,2Ø1,124,2Ø5,62,125,125,
   245,23Ø,24Ø,15,15,15,15,2Ø5.75,125,241,23Ø,15,245,254,1Ø,
   56,2
24 '
25 DATA 198,7,198,48,2Ø5,49,125,241,2Ø1,254,48,216,254,58,56,
   9,254,65,216,254,71,48,5,214,7,214,48,2Ø1,55,2Ø1,2Ø5,29
26 '
27 DATA 125,2Ø5,89,125,56,248,24,211,2Ø5,89,125,216,24,2Ø5,
   2Ø5,129,125,2Ø5,11Ø,125,7,7,7,7,79,2Ø5,11Ø,125,129,119,
   43,2Ø1
28 '
29 DATA 2Ø5,126,125,2Ø5,47,125,16,248,2Ø1,2Ø5,39,125,2Ø5,126,
   125,42,255,124,2Ø5,43,125,2Ø5,57,125,2Ø5,39,125,126,2Ø5,
   62,125,2Ø5
3Ø '
31 DATA 47,125,2Ø5,29,125,254,1Ø,4Ø,34,254,91,4Ø,33,254,88,
   2Ø2,146,127,2Ø5,12Ø,125,56,235,7,7,7,7,71,2Ø5,29,125,254
32 '
33 DATA 88,2Ø2,146,127,2Ø5,12Ø,125,56,243,128,119,35,24,196,
   2Ø5,35,125,43,24,19Ø,2Ø5,39,125,6,1,2Ø5,144,125,2Ø5,2Ø1,
   1,42
34 '
35 DATA 255,124,3Ø,128,14,2,2Ø5,57,125,2Ø5,39,125,6,8,126,
   2Ø5,62,125,2Ø5,47,125,35,29,2Ø2,149,127,16,242,2Ø5,43,
   125,13
36 '
37 DATA 32,228,2Ø5,43,125,24,221,2Ø5,39,125,2Ø5,126,125,2Ø5,
   29,125,254,74,194,146,127,237,115,7,125,49,9,125,217,8,
   253,225
38 '
39 DATA 221,225,225,2Ø9,193,241,217,8,225,2Ø9,193,241,237,
   123,7,125,42,255,124,233,245,213,2Ø5,73,Ø,2Ø9,241,237,
   115,7,125,49
4Ø '
41 DATA 29,125,245,197,213,229,8,217,245,197,213,229,221,
   229,253,229,217,8,237,123,7,125,2Ø5,2Ø1,1,33,28,125,17,
   221,124,14
42 '
43 DATA 3,6,4,2Ø5,43,125,26,2Ø5,49,125,19,26,2Ø5,49,125,19,
   2Ø5,39,125,126,2Ø5,62,125,43,126,2Ø5,62,125,43,16,228,2Ø5
44 '
45 DATA 43,125,13,32,22Ø,237,91,5,125,33,1,125,1,3,Ø,237,176,
   195,146,127,2Ø5,39,125,33,6,125,2Ø5,126,125,2Ø5,29,125
46 '
47 DATA 254,66,194,146,127,42,5,125,17,1,125,1,3,Ø,237,176,
   43,58,4,125,167,4Ø,12,151,5Ø,4,125,17,68,126,2Ø5,35
48 '
49 DATA 125,24,3,17,75,126,114,43,115,43,54,195,2Ø5,43,125,
   62,74,2Ø5,49,125,33,Ø,125,195,23,126,5Ø,4,125,2Ø5,35,125
5Ø '
51 DATA 195,146,127,2Ø5,39,125,6,3,2Ø5,144,125,2Ø5,29,125,
   2Ø5,49,125,119,2Ø5,29,125,254,87,194,146,127,2Ø5,35,125,
   2Ø5,63,2
52 '
53 DATA 221,33,25Ø,124,42,253,124,237,91,255,124,237,82,35,
   62,1Ø2,2Ø5,31,2,62,85,2Ø5,31,2,6,6,221,126,Ø,2Ø5,31,2
54 '
55 DATA 221,43,16,246,37,25Ø,7Ø,127,62,6Ø,2Ø5,31,2,151,2Ø5,
   31,2,2Ø5,1Ø6,127,24,238,151,189,4Ø,12,62,6Ø,2Ø5,31,2,125
56 '
57 DATA 2Ø5,31,2,2Ø5,1Ø6,127,62,12Ø,2Ø5,31,2,237,75,251,124,
   121,2Ø5,31,2,12Ø,2Ø5,31,2,195,146,127,71,123,2Ø5,31,2,122
58 '
59 DATA 2Ø5,31,2,131,79,26,2Ø5,31,2,129,79,19,16,247,121,
   195,31,2,2Ø5,2Ø1,1,49,Ø,192,33,211,124,2Ø5,167,4Ø,151,5Ø
6Ø '
61 DATA 4,125,2Ø5,43,125,33,Ø,125,62,36,2Ø5,49,125,2Ø5,29,
   125,2Ø5,49,125,254,68,2Ø2,228,125,254,77,2Ø2,153,125,254,
   66,2Ø2
62 '
63 DATA 164,126,254,74,2Ø2,23,126,254,8Ø,2Ø2,234,126,254,82,
   2Ø2,75,126,254,87,2Ø2,243,126,254,83,2Ø2,25,26,62,8,2Ø5,
   49,125,24,195
```

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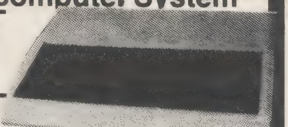

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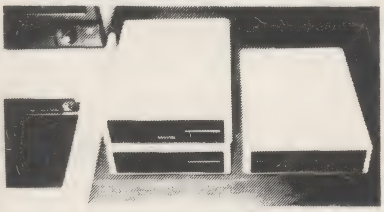

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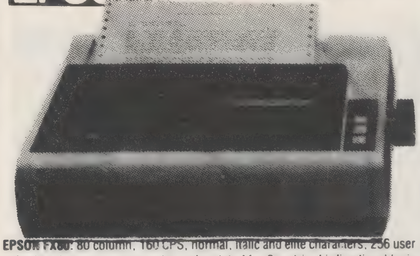

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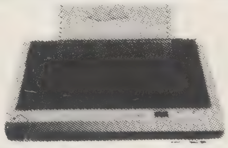

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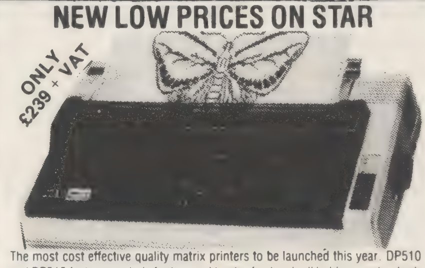

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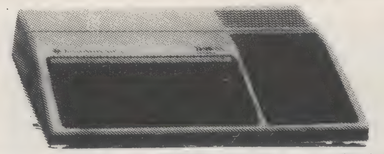

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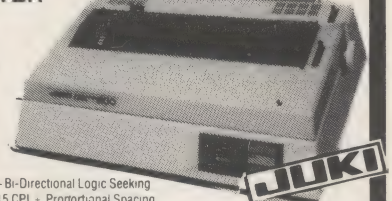

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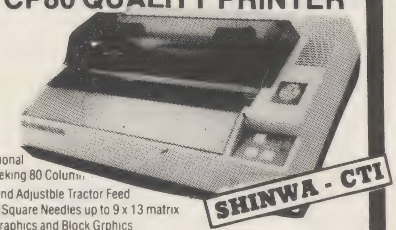

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LEARNING FORTH PART 4

Last month I dealt with the structures that FORTH uses to control the flow of execution within a program and also began to explain how various dictionary entries are stored and how you can create your own 'defining words'.

We'll now see how we can use <BUILDS . . . DOES> to produce a word which can define an array. For the first example we want a word ARRAY which, when used as follows:

```
n ARRAY name
```

will set up a dictionary entry called 'name' which will be an entry of n+1 elements (0 to n), so that when 'name' is used, for example:

```
m name
```

it will return the memory address of the mth element of the array. (I'm using arrays with subscripts 0 to n as this will be familiar to most BASIC users.)

If this all sounds a little confusing then the idea compares to the use of BASIC's DIM function, comprising DIM name (n) which sets up the array, and name (n) which lets you access any element of the array. So we need a word whose actions are:

(define-time action) Allocate space in the dictionary for the array.

(run-time action) Given a number, m, on the stack, return the physical address of the mth element of the array.

Listing 1 gives a definition for the word ARRAY which will do what I have described. It could be used, for example, as:

TAKE IN CRA

This would set up an array called COUNTERS with 21 elements (0-20). Using:

```
10 COUNTERS
```

would give the address of element 10, so that:

```
10 COUNTERS @
```

would return the number held in this element of the array, and:

```
14 10 COUNTERS !
```

would store the number 14 in element 10 of the array.

The way the define-time action of the word works is as follows. <BUILDS sets up the dictionary header for the new word, the expression 1 + 2 ★ ALLOT adds one to the number on top of the stack, multiplies the result by two and sets aside (ALLOTs) that many 'bytes' of memory in the dictionary for the parameter field of the new word. Remember, given a number n, we want n+1 elements which take up 2★(n+1) bytes of memory as each number takes two bytes.

ALLOT works in much the same way that C, and , can be used to enclose one and two bytes of memory in the dictionary but ALLOT can set aside as many as necessary and also does not store any numbers in these bytes, it just makes the space available.

The way the run-time action works is quite simple. Assuming you have used your new array to store some numbers, then whenever you want to access the array (ie get a number from it or put a number in it) you use an expression like

```
7 COUNTERS
```

The word COUNTERS leaves the address of its parameter field (the actual array space) on the stack and calls the run-time action of its defining word ARRAY to use this number. The expression in ARRAY:

```
SWAP 2 * +
```

calculates the address of that particular element of the array.

As this is the first example I'll run through this run-time action bit by bit. When the run-time action of ARRAY is called there are two numbers on the stack (these are the required element (10) and the address of the zeroth element of the array (COUNTERS)).

The expression SWAP 2 ★ leaves on the stack (address of the zeroth element) and (offset in bytes to required element). Then + leaves on the stack the actual address of the required element, which can be used by @ and ! to fetch a value stored or to store a new one.

The word ARRAY can be used to define any number of unique arrays with any number of elements (memory permitting) in the same way that VARIABLE can create lots of different variables.

CHECKING IT OUT

While the definition of ARRAY may seem particularly short for such a powerful command, it does have serious drawbacks. When a new array is defined it does not initialise the contents: more seriously, when the array is used there is no error-checking to see if what you are trying to do is 'legal'.

For example in Spectrum BASIC, if you set up an array using:

```
DIM p(10)
```

and then try:

```
LET a = p(12)
```

the program will stop with a "Bad subscript" error message.

It is very important to make sure that you stay within the limits of your array, because if you change the contents of a memory address just outside it, you will corrupt the dictionary entry of an adjacent word. This usually means that sooner or later your program will 'crash' seriously. Listings 2 and 3 give definitions for a few words that overcome these difficulties.

The new defining word ARRAYCHECK in Listing 3 is a word which will set up arrays in the dictionary but will initialise all the elements of the array to zero at define-time, and at run-time will check that you are attempting to access a valid element.

To explain, at define time the define-time action takes a number off the stack (call it n) and adds one to it; this is the number of elements. This number is duplicated and stored in the first two bytes of the parameter field. The same number is then used to control the upper limit of a DO . . . LOOP which repeatedly encloses the number 0 in the dictionary by

```
( LISTING 1 - DEFINING WORD FOR ONE DIMENSIONAL ARRAYS)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)

: ARRAY <BUILDS ( N -)
  1+ 2 * ALLOT
   DOES> ( N,ADDR-ADDR)
   SWAP 2 * + ;
```

Listing 1

using , (comma). For example, if we set up an array using:

```
3 ARRAYCHECK TEST
```

then the define-time action of ARRAYCHECK would set up a dictionary entry like the one shown in Fig. 1. The first two bytes in the parameter field contain the number of elements in the whole array and the rest of the parameter field is initialised to contain zeros.

Error-checking, of course, makes the run-time action of ARRAYCHECK a little more complicated, so I have defined two words CHECKBOUND and ERRORMESSAGE to make the definition of ARRAYCHECK clearer. Whenever our new array TEST is used, it calls the run-time action of ARRAYCHECK. At this time the top two numbers on the stack will be the element of TEST we require and the address of TEST's parameter field.

CHECKBOUND uses these two numbers to fetch the contents of the first two bytes of this parameter field. This contains the number of elements in the array or, to put it another way, the upper limit plus one. CHECKBOUND returns a value to the top of the stack which is one, ie true, if the required element is (greater than or equal to zero) AND (less than or equal to the upper limit).

If CHECKBOUND returns 'true' then ARRAYCHECK carries on and works out the address of the required element of the array as before. (The 2 + is to take into account the two bytes taken up to hold the count for the number of elements.)

If CHECKBOUND returns 'false' then ERRORMESSAGE is called, which uses the top two numbers on the stack (ie required element, parameter field address) to produce a suitably useful message. Execution of any program running is then stopped. Most programs in FORTH would probably use ABORT to abort the program and clear the stack, but in Abersoft's version ABORT also clears the screen so that your error message would promptly disappear. So I have used the expression SP! QUIT to clear the data stack and quit execution of the current program.

To see how this works in practice, try:

```
3 ARRAYCHECK TEST
```

and then attempt to use an element that is out of bounds, for example:

CRA 15

The computer will respond:

```
ERROR! Value 6 out of bounds
Range allowed is Ø-3
ok
```

Clever, eh?

2-D ARRAYS

Listing 4 gives the definition of a word that will create two dimensional arrays (ie rows and columns). This definition is a non-checking, non-initialising one. At first sight this definition of 2-D seems more complex than that of ARRAY, but it is essentially the same. The word 2-D is used in the form:

```
row-limit  column-limit  2-D  name
```

For example:

```
8  8  2-D  CHESSBOARD
```

Any element of the array would be accessed using:

```
row  column  name
```

For example:

```
4  2  CHESSBOARD
```

The define-time action of 2-D first of all has to save in the parameter field of the new word the number of columns in the array. Then the total number of bytes which the array will occupy is calculated:

```
number of bytes = 2*((limit for
rows + 1)*(limit for columns + 1))
```

and these are set aside in the dictionary using ALLOT as defined earlier.

The run-time action of 2-D expects three numbers on the stack (row, column, parameter field address of new array), and it calculates the address of the required element. All the elements of the array are stored in order in the dictionary; for example, if we had defined an array using:

```
2  3  2-D  EXAMPLE
```

the elements would be stored in the dictionary in the following order:

```
(Ø,Ø),(Ø,1),(Ø,2),(Ø,3),(1,Ø),
(1,1), . . . . . . . . . ,(2,3)
```

so that to calculate where the required element is in the list you work out:

```
((required row)*(number of
columns) + required column
```

For example, in the above 2-D array element (1,1) is:

```
(1*4) + 1 = 5th element
```

Remember our list begins with the zeroth element, so the offset in bytes from the parameter field address is in this case (2★5) plus the two bytes used to store the number of columns.

I have included in all my definitions comments at the right hand side to indicate the contents of the stack at various points.

Listing 5 gives a defining word 2-DCHECK which operates similarly to 2-D, but initialises the elements of the array to zero when the array is defined and at run time checks that both subscripts (row and column) are within the limits of the array.

In this case the define-time action of 2-DCHECK needs to store in the parameter field of the new word both the number of rows and the number of columns in the array. The run-time action of 2-DCHECK is essentially similar to that of ARRAYCHECK, but in this case we need to check for both row and column limits. Figure 2 gives a diagrammatic view of the dictionary entry for a word defined as:

```
3  4  2-DCHECK  BOARD2
```

This array has (3 + 1) ★ (4 + 1) = 20 elements, and the number of columns and the number of rows are stored as the first two numbers (four bytes) in the parameter field of BOARD2.

So, the run-time action of 2-DCHECK uses the numbers provided for the required row and column, along with the parameter field address of the array, as parameters to pass to CHECKBOUND to see if the subscripts are in range. If either subscript is wrong then a suitable error message is printed as before, only this time I have arranged that 2-DCHECK lets you know whether the mistake is in the row or column.

HERE BE MONSTERS

Listings 6 and 7 show how flexible the use of defining words is in constructing your own dictionary entries. This example sets up a somewhat larger and peculiar array for holding

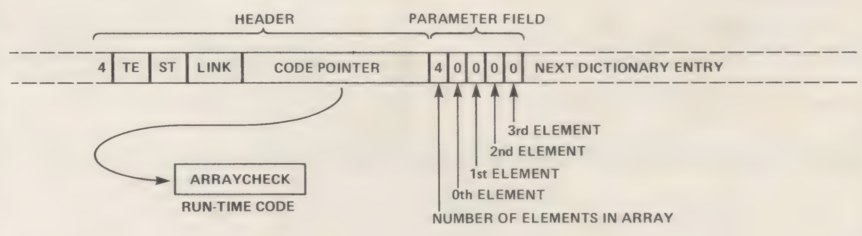

Fig. 1 A typical ARRAYCHECK dictionary entry.

```
( LISTING 2 - ASSOCIATED WORDS FOR SELF CHECKING ARRAYS)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)

: CHECKBOUND ( N,ADDR-N,ADDR,FLAG)
  OVER OVER @   ( N,ADDR,N,UL+1)
  OVER >        ( N,ADDR,N,[UL+1>N])
  SWAP -1 >     ( N,ADDR,[UL+1>N],[UL>=0])
  AND           ( N,ADDR,FLAG[FLAG=1 IF VALID ELEMENT])
;

: ERRORMESSAGE ( N,ADDR-)
  CR SWAP ." ERROR! Value " . ." out of bounds."
  CR ." Range allowed is 0-" @ 1 - . CR
;
```

Listing 2

```
( LISTING 4 - DEFINING WORD FOR 2-D NON-CHECKING ARRAYS)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)

: 2-D <BUILDS ( NUM. OF ROWS,NUM. OF COLS -)
      1+ DUP , SWAP 1+ * 2 * ALLOT
     DOES> ( ROW,COL,ADDR-ADDR)
      ROT OVER @ ( COL,ADDR,ROW,NO.OF COLS)
      * ROT +     ( ADDR,ELEMENT)
      2 * + 2+    ( ADDR)
;
```

Listing 4

```
( LISTING 3 - DEFINING WORD FOR SELF CHECKING 1-D ARRAYS)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)

: ARRAYCHECK <BUILDS ( N-)
    1+ DUP , 0 DO 0 , LOOP
  DOES> ( N,ADDR-ADDR )
   CHECKBOUND IF SWAP 2 * + 2+ ( ADDR)
   ELSE ERRORMESSAGE SP! QUIT THEN ;
```

Listing 3

```
( LISTING 5 - DEFINING WORD FOR 2-D SELF CHECKING ARRAYS)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)

: 2-DCHECK <BUILDS ( NUM.OF ROWS,NUM.OF COLUMNS)
    1+ DUP , SWAP 1+ DUP ,    ( COLS+1,ROWS+1)
    * 0 DO 0 , LOOP
  DOES> ( ROW,COL,ADDR-ADDR)
   CHECKBOUND                ( CHECKS IF COL IN RANGE )
   IF ROT SWAP 2+            ( COL,ROW,ADDR+2)
    CHECKBOUND               ( CHECKS IF ROW IN RANGE)
    IF 2 - DUP @             ( COL,ROW,ADDR,NO.OF COLS)
     ROT * ROT + 2 * + 4 +   ( ADDR OF REQUIRED ELEMENT )
    ELSE ERRORMESSAGE ." for row of array." SP! QUIT
   THEN
  ELSE ERRORMESSAGE ." for column of array." SP! QUIT
 THEN ;
```

Listing 5

the names and attributes of 19 different monsters that wish to do battle with you in my FORTH version of that famous game THE-VALLEY.

While the details of the defining word MARRAY will not be clear until the end of this series of articles (as it relies heavily on moving strings of text about before it encloses them in the dictionary) the general idea is quite instructive. The defining word MARRAY has a define-time action which requires no values upon the stack, but instead prompts the user to type in the details for the four different fields of this array. When used as:

```
MARRAY MONSTERS
```

you can type in repeatedly the names, physical strenths and psi strengths of your monsters along with a code letter which determines the scenes that a particular nasty creature can be present in. All this information is thus stored in the array MONSTERS which is set up to contain (diagrammatically):

nameØ (15 letters max)	strengthØ (Ø-255)	psi-strengthØ (Ø-255)	code-letterØ (1 letter)
name1	strength1	psi-strength1	code-letter1
name2	strength2	psi-strength2	code-letter2
.			
.			
.			
name18	strength18	psi-strength18	code-letter18

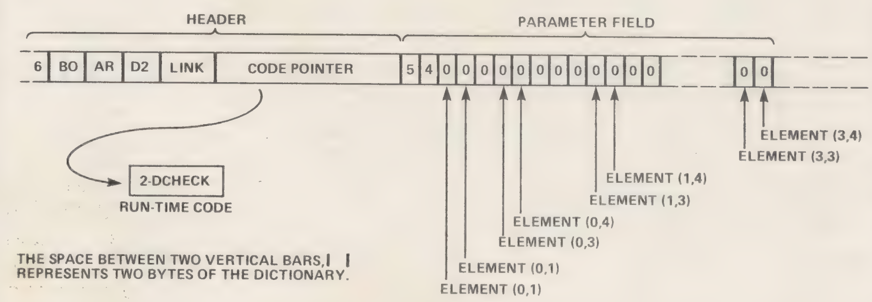

Fig. 2 A typical 2-DCHECK dictionary entry.

The run-time action of the word MARRAY takes two numbers off the stack (required element (0-18), required field (0-3)), for example:

```
4  MNAME  MONSTERS
```

where we have defined MNAME, MSTRENGTH etc as constants to make the program clearer. The run-time action returns either the required address for MSTRENGTH, MPSI and MCODE or an address and a number for MNAME (address of first letter of monster's name and a count of the number of letters in its name). This allows the name to be printed using the FORTH word TYPE.

Next month I shall be dealing with input and output, which should clarify the details of this defining word and allow us to produce something like it for names and addresses, dates of birth and so on.

A RANDOM WALK

It is quite difficult in such a series as this to provide numerous small examples to show the use of a particular feature of a language, so the next few listings demonstrate, using fairly complex but nicely compatible

programs, many of the aspects of FORTH that I have covered so far.

Listing 8 is a few words to provide a random number generator, which is missing from FORTH. The generator uses the same method as the built-in RND function on the Spectrum, and the mathematical method is described fully on pages 56 and 57 of the manual. To use the random function type:

```
n   RND
```

where n is a positive integer, and a random number between zero and n−1 will be returned to the stack. Like the BASIC version you can repeat a given series of random numbers by using:

```
n   RAND
```

This initialises the seed for the generator.

One particular feature of RAND is that if you type:

```
Ø   RAND  32
```

the program uses the Spectrum clock to initialise the seed.

```
HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH
H*****************************H
HHH.HHH.H.HHH.HHHHHHH.HHHHHHH*H
H...H.H.H...H.H.....H.H......*H
H.HHH.H.HHHHH.H.HHH.HHH.H.HHH*H
H.H...H.H..........H...H.H.H*H
H.H.HHH.H.HHHHH.HHH.H.HHH.H.H*H
H.H.......H...H...H.H...H*****H
H.HHHHH.HHHHH.HHHHH.HHHHH*HHHHH
H.....H.H.H......*********HoooH
H.HHHHH.H.HHH.HHH*HHHHHoHHHoHHH
H.H.........H...H*HoHoooHoooHoH
H.HHH.HHH.HHH.H.H*HoHHHHHoHHHoH
H...H.H...H...H***ooooooooHoooH
H.H.HHHHH.H.HHH*HHHHHoHHHoHoHHH
H.H.......H.H.H*HoooooH.HoooH.H
H.HHH.H.HHH.H.H*HHHoHHH.HHHoH.H
H...H.H.H...H..***HoH.....HoH.H
HHHHH.HHH.H.HHHHH*HHH.HHH.HHH..
H.........H......**************
HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH
```

Fig. 3 Typical maze and route out.

Listings 9-12 use a 2-dimensional array to hold an array of characters which represent a maze. The method of construction of the maze and the functional definitions of all the associated words are given in the glossary, Listings 13 and 14. Executing TEST will produce the maze shown in Fig. 3. Change 1 RAND to 0 RAND and TEST will produce a different maze each time.

Listings 16-18 use the maze produced by TEST to show how, from any position within the maze, an exit can be found (providing one exists). The method is recursive, ie the word SEEKEXIT actually contains a call of itself and this necessitates, in Abersoft's FORTH, the use of the word PGSMUDGE, as explained in the glossary. Again the method used to find the exit and the functional definitions of the associated words are contained in the glossary, Listings 19 and 20.

If you execute TEST (with 1 RAND in the definition as shown), followed by FINDEXIT, then the output should be as shown in Fig. 3.

I hope this month's article has whetted your appetite for a little more FORTH, as next month I'll be explaining how you can communicate with your program (ie input/output), how FORTH handles the RAM disc, and how you can combine this with what we know of defining words to manipulate and store text within the dictionary.

```
( LISTING 6 - DEFINING WORDS FOR 'MONSTER ARRAY')
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
0 CONSTANT MNAME    1 CONSTANT MSTRENGTH
2 CONSTANT MPSI     3 CONSTANT MCODE
: MARRAY <BUILDS
  19 0 DO
   CLS ." TYPE IN NAME OF MONSTER" CR
   QUERY 34 ( ASCII " ) TEXT PAD DUP 15 + SWAP
   DO I C@ C, LOOP
   CR ." TYPE IN MONSTER'S STRENGTH" CR QUERY INTERPRET C,
   CR ." TYPE IN MONSTER'S PSI STRENGTH" CR QUERY INTERPRET C,
   CR ." TYPE IN CODE FOR SCENE SELECTION" CR KEY DUP EMIT C,
 LOOP
 DOES>   ( ELEMENT,FIELD,BASE ADDRESS)
  OVER DUP MNAME = OVER MSTRENGTH = OR
  OVER MPSI = OR SWAP MCODE = OR NOT -->
```

Listing 6

```
( LISTING 7 - MONSTER ARRAY CONTINUED)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
  IF CR ." ERROR! INVALID FIELD SUPPLIED" CR SP! QUIT THEN
  ( CALCULATE OFFSET FOR CHOSEN FIELD )
  ( ELEMENT,FIELD,BASE ADDR.)
  OVER ( E,F,BA,F)
  CASE MSTRENGTH OF 15 + ENDOF
       MPSI      OF 16 + ENDOF
       MCODE     OF 17 + ENDOF
  ENDCASE  ( E,F,OFFSET BASE ADDR.)
 ROT ( F,OBA,E) DUP 18 > OVER 0< OR
 IF CR ." ERROR! OUT OF BOUNDS IN MARRAY" SP! QUIT THEN
 18 * + ( F,ELEMENT ADDR)
 SWAP MNAME = IF COUNT ELSE C@ THEN
;
```

Listing 7

```
( LISTING 8 - RANDOM NUMBER GENERATOR)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
0 VARIABLE SEED
: SEEDON ( -NEXT VALUE OF SEED)
  SEED @ 75 U* 75 0 D+ OVER OVER U< - - 1 - DUP SEED ! ;
: RAND ( VALUE FOR SEED-)
  DUP 0= IF 23672 C@ SWAP DROP THEN SEED ! ;
: RND ( N-PSEUDO RANDOM NUMBER BETWEEN 0 AND N-1 )
  SEEDON U* SWAP DROP ;
2 LOAD 3 LOAD 4 LOAD 5 LOAD 8 LOAD 9 LOAD
```

Listing 8

```
( LISTING 9 - WORDS FOR MAZE DRAWING)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
: VAR VARIABLE ;     : CON CONSTANT ;    ( MAKES TYPING EASIER )
31 VAR SCREEN-WIDTH   20 VAR SCREEN-HEIGHT   2 VAR WALLSIZE
0  VAR MAXROW         0  VAR MAXCOL          0 VAR LINES
: SETPARAMS ( -)
  WALLSIZE @ SCREEN-WIDTH @ OVER / * MAXCOL !
  WALLSIZE @ SCREEN-HEIGHT @ OVER / * MAXROW !
  MAXROW @ MAXCOL @ * WALLSIZE @ DUP * / 100 * 127 / LINES ! ;
72 ( ASCII H) CONSTANT HEDGE    46 ( ASCII .) CONSTANT WALKWAY
0 VAR ROW-START    0 VAR COL-START    0 VAR ROW-DIR
0 VAR COL-DIR      0 VAR END-ROW      0 VAR END-COL
SETPARAMS  ( SETS VALUES FOR MAXROW & MAXCOL)
MAXROW @ MAXCOL @ 2-DCHECK MAZE    ( SETS UP ARRAY SPACE)
: CPLOT ( ASCII CODE,ROW,COL)
  OVER OVER AT ROT DUP EMIT ROT ROT MAZE ! ;
```

Listing 9

```
( LISTING 10 - MAZE DRAWING CONTINUED)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
: CPOINT ( ROW,COL-ASCII CODE) MAZE @ ;
: PICKSTART WALLSIZE @ MAXCOL @ OVER / 1+ RND * COL-START !
     WALLSIZE @ MAXROW @ OVER / 1+ RND * ROW-START ! ;
: PICKDIRECTION 4 RND 1+ CASE
  1 OF  1 COL-DIR !  0 ROW-DIR ! ENDOF
  2 OF -1 COL-DIR !  0 ROW-DIR ! ENDOF
  3 OF  0 COL-DIR !  1 ROW-DIR ! ENDOF
  4 OF  0 COL-DIR ! -1 ROW-DIR ! ENDOF
  ENDCASE ;
: FINDEND WALLSIZE @ COL-DIR @ * COL-START @ + END-COL !
          WALLSIZE @ ROW-DIR @ * ROW-START @ + END-ROW ! ;
: CHECKEND ( -FLAG) END-COL @ 0<
   MAXCOL @ END-COL @ < OR END-ROW @ 0< OR MAXROW @ END-ROW @ <
   OR IF 1 ELSE END-ROW @ END-COL @ CPOINT HEDGE = THEN ;
```

Listing 10

```
( LISTING 11 - MAZE DRAWING CONTINUED)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
: PLOTLINE HEDGE ROW-START @ COL-START @ CPLOT WALLSIZE @  0 DO
  ROW-START @ ROW-DIR @ + ROW-START !
  COL-START @ COL-DIR @ + COL-START !
  HEDGE ROW-START @ COL-START @ CPLOT
  LOOP ;
: TRYLINES ( FLAG-FLAG)
  BEGIN DUP 0= IF PICKSTART THEN DROP 0 5 0
  DO PICKDIRECTION  FINDEND CHECKEND 0=
   IF PLOTLINE DROP 1 LEAVE THEN
  LOOP
  INKEY 32 = IF DROP 2 THEN DUP
  UNTIL ;
```

Listing 11

```
( LISTING 12 - MAZE DRAWING CONTINUED)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)

: DRAWMAZE
  0 LINES @ 0 DO TRYLINES DUP 2 = IF LEAVE THEN LOOP DROP ;

: DRAWBORDER
  MAXROW @ 1+ 0 DO HEDGE I 0 CPLOT HEDGE I MAXCOL @ CPLOT LOOP
  MAXCOL @     1 DO HEDGE 0 I CPLOT HEDGE  MAXROW @ I CPLOT LOOP
  MAXCOL @ 1 DO MAXROW @ 1 DO WALKWAY I J CPLOT LOOP LOOP ;

: DISPLAYMAZE
  CLS MAXROW @ 1+ 0 DO MAXCOL @ 1+ 0 DO
  J I MAZE @ EMIT LOOP CR LOOP ;

: TEST CLS 1 RAND DRAWBORDER DRAWMAZE 20 0 AT ;
```

Listing 12

```
( LISTING 13 - MAZE DRAWING EXPLANATION)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
To draw a random pattern maze within a space limited by screen
height and screen width and where the gap between each parallel
wall shall be equal to the value stored in WALSIZE less one.
 First scale the boundaries of the maze so that there is always
the same space between adjacent parallel walls. The maze is
going to be drawn by plotting a series of small walls of length
WALSIZE +1. Calculate roughly how many of these small walls are
needed to fill the maze and store the number in LINES.
 The maze is made up of HEDGES letter H and WALKWAYS character
To draw the maze, draw a border and repeatedly for the number
of LINES  1) Pick a random starting point
          2) pick a random direction
     3) caculate the end point of the short wall
4) if it is not a hedge or outside the array then plot the wall.
```

Listing 13

```
( LISTING 14 - MAZE DRAWING: GLOSSARY OF WORDS)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
 NAME      STACK EFFECTS      DESCRIPTION
CPLOT (ascii code,row,col-) plots the given charcter both in the
      the array MAZE and on the screen.
CPOINT (row,col-ascii code) returns the character stored in the
       array MAZE at point row,col.
PICKSTART (-) selects a random starting point for new wall. Puts
          position in ROW-START & COL-START.
PICKDIRECTION (-) selects a random direction for wall. Puts
              values in ROW-DIR & COL-DIR
FINDEND (-) calculates end-point of possible new wall. Returns
        position in END-ROW & END-COL.
CHECKEND (-flag) Returns a vaue 1 on the stack if the end point
         is out of the array or is a HEDGE.
```

Listing 14

```
( LISTING 14 CONT. - MAZE DRAWING: GLOSSARY OF WORDS CONT.)
PLOTLNE (-) draws a wall WALLSIZE +1 long from
        ROW-START,COL-START to ROW-END,COL-END.
TRYLINES (flag-flag) if the flag on the stack is zero then
a new starting point is calculated for the next wall. Otherwise
the next wall will start from the end of the last wall plotted.
Five attempts are then made to draw a new wall. If it is not
possible then a new starting point is chosen.
 This routine can be interrupted by pressing the SPACE key.
 This will end the drawing of the maze.
 A flag is left on the stack indicating 1,successfull drawing
 of wall. 2,abandon drawing of maze.
DRAWMAZE (-) controls the drawing of the number of walls.
DRAWBORDER (-) draws a border for the maze.
DISPLAYMAZE (-) draws array containing maze on the screen.
TEST (-) will always produce the same maze.(Change 1 to alter.)
```

Listing 14 (continued)

```
( LISTING 16 - LEAVE MAZE ROUTINES)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)

: UNFILL
  MAXROW @ 1 DO MAXCOL @ 1 DO J I CPOINT HEDGE =
    IF ( DO NOTHING) ELSE WALKWAY J I MAZE ! THEN
  LOOP LOOP ;
: MAKEEXIT WALKWAY MAXROW @ 2 - MAXCOL @ MAZE !
 WALKWAY  MAXROW @ 1 -  MAXCOL @  MAZE ! ;

0 VAR EASTLIMIT     0 VAR SOUTHLIMIT
0 CON NORTHLIMIT    0 CON WESTLIMIT
0 VAR EXITFOUND
111 ( ASCII o) CONSTANT FOOTSTEP
 42 ( ASCII *) CONSTANT PATHMARK
: PGSMUDGE SMUDGE ; IMMEDIATE
```

Listing 16

```
( LISING 17 - LEAVE MAZE ROUTINES CONT.)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
: SETLIMITS MAXCOL @ EASTLIMIT ! MAXROW @ SOUTHLIMIT ! ;
SETLIMITS
: SEEKEXIT ( LAT,LON-) PGSMUDGE R> ROT ROT
  >R >R I NORTHLIMIT   = I SOUTHLIMIT @ = OR
  I' WESTLIMIT = OR I' EASTLIMIT @ = OR R> R> ROT
  IF 1 EXITFOUND !
   ELSE
   OVER OVER FOOTSTEP ROT ROT CPLOT
   ( TRY EAST)
   OVER OVER 1+ CPOINT WALKWAY =
    IF OVER OVER 1+ SEEKEXIT THEN
   EXITFOUND @ NOT
   IF ( TRY SOUTH)
   OVER 1+ OVER CPOINT WALKWAY = --> ( COMPILE NEXT SCREEN)
```

Listing 17

```
( LISING 17 - LEAVE MAZE ROUTINES CONT.)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
    IF OVER 1+ OVER SEEKEXIT THEN
   THEN EXITFOUND @ NOT
   IF ( TRY WEST)
   OVER OVER 1 - CPOINT WALKWAY =
    IF OVER OVER 1 - SEEKEXIT THEN
    THEN EXITFOUND @ NOT
   IF ( TRY NORTH)
   OVER 1 - OVER CPOINT WALKWAY =
    IF OVER 1 - OVER SEEKEXIT THEN
   THEN
  THEN EXITFOUND @ IF PATHMARK ROT ROT CPLOT
  ELSE DROP DROP THEN >R PGSMUDGE ;
: LEAVEMAZE ( -) UNFILL MAKEEXIT 0 EXITFOUND ! DISPLAYMAZE
  1 1 SEEKEXIT 20 0 AT EXITFOUND @ 0= IF ." NO WAY OUT! "THEN ;
```

Listing 17 (continued)

```
( LISTING 18 - EXPLANATION OF METHOD TO LEAVE MAZE)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
Assume the maze is a rectangular enclosure divided into squares
each square being either covered by a hedge or not. The
perimeter squares are all hedge covered except for one or more
exits. You are released somewhere inside the maze and you have
to find your way to an exit. You may move from square to square
in any direction except diagonally, but you cannot cross a
hedge. The maze is represented in the two dimensional array
MAZE. Letter 'H' represents a hedge and character '.' a pathway.
( To find a path from square to an exit,a possible solution:-)
IF square S is on the perimeter THEN exit from maze
ELSE try heading East
 IF no exitfound yet THEN try heading South
 IF no exitfound yet THEN try heading West
 IF no exitfound yet THEN try heading North    ( end)
```

Listing 18

```
( LISTING 19 - EXPLANATION OF METHOD TO LEAVE MAZE CONT.)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
We can further refine 'try heading East' ( the others will be
similar)
( Try heading east)
IF S's eastern neighbouring square is a pathway THEN
   find a path from S's eastern neighbouring square to an exit.
But 'find a path from...etc.' is the same as the original
problem. So we can use a recursive word ( i.e. one that contains
a call of itself) that expects on the stack the coordinates of
its starting square.
The proceedure marks each square it visits with a 'footstep'
so that it doesn't go round in circles. The proceedure when
it has found an exit marks each square which lies on the path
with an asterisk (*). The final picture of the maze will show
the path and any blind alleys which were followed ( listing 21).
```

Listing 19

```
( LISTING 20 - GLOSSARY OF WORDS FOR LEAVE MAZE ROUTINES)
( 48K SPECTRUM   ABERSOFT fig-FORTH 1.1A)
UNFILL (-) Empties the maze of pathmarks and footsteps. Gives
           you a 'clean' maze withouthaving to re-draw it.
MAKEEXIT (-) forms an exit in the bottom right hand corner.
PGSMUDGE (-) Something I've not explained yet but this word
             has to be used to form a RECURSIVE definition.
SETLIMITS (-) Initialises the variables that SEEKEXIT uses to
              determine if the exit of the maze has been found.
SEEKEXIT ( row,col-) uses the row & column provided on the
stack as the starting point from which to try and find an exit.
The use of the words R> & >R will be explained in a further
article. BE CAREFUL to type an equal number of R>'s and >R's
as shown in the listing!
LEAVEMAZE (-) will give an output as listing 21 if it uses
the maze produced by TEST.
```

Listing 20

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M. D. Buxton

NON-RANDOM RANDOM NUMBERS

The whole point of random numbers is that they are unpredictable, so a program that makes use of them can be very difficult to debug. This article offers a simple solution using a resource at hand in every computer.

Have you ever needed a set of random numbers for debugging, testing or other purposes? Perhaps you have used a simple subroutine such as this which will generate 100 random numbers in the range 1-10:

```
10010 FOR I=1 TO 100
10020 R=RND(10)
10030 PRINT R
10040 NEXT I
10050 RETURN
```

However, the random numbers will not be the same every time that subroutine is used. One way of getting round this is to put the numbers in an array and extract them as required:

```
10 DIM R(100)
.
.
.
10010 FOR I=1 TO 100
10020 R=RND(10)
10030 R(I)=R
10040 NEXT I
10050 RETURN
```

Another simple subroutine in the same program can be used to extract these random numbers so that they reappear in the same order:

```
20010 FOR I=1 TO 100
20020 PRINT R(I)
20030 NEXT I
20040 RETURN
```

Unfortunately, the sequence of random numbers will stay unchanged only during one run. The advantage over the techniques used in the first subroutine is that the array can be examined as many times as necessary during the run. A disadvantage is that large arrays need a lot of memory. Where practicable, integer arrays should be used in this sort of application.

How about using READ and DATA statements? The data read in would be the same for every run! Let's see:

```
10 DIM R(10)
20 DATA 1,9,4,4,3,7,8,5,6,2
30 FOR I=1 TO 10
40 READ R
50 R(I)=R
60 NEXT I
.
.
.
20010 FOR I=1 TO 10
20020 PRINT R(I)
20030 NEXT I
20040 RETURN
```

Well, a program based on this is not so bad for only 10 'random' numbers but what about a 100 or a 1000? For some purposes, it may not be necessary to hold the numbers in an array (economising on memory) but rather use READ and RESTORE. There is still the problem of slaving over a hot keyboard, keying in that innumerable 'random' data.

NON-RANDOM RANDOMS

There is an easier way, if you do not mind the fact that the numbers generated are not genuinely random and do appear to have a bias in their distribution. Have you PEEKed your computer's ROM to find a mass of seemingly random numbers in the range 0 to 255? The Level II ROM of the TRS-80 Model I occupies addresses 0 to 12287, so there are plenty of these 'random' numbers available. PEEKing addresses other than those in the ROM reveals more numbers but these are not always reproducible. The contents of the addresses in the ROM do not change in the course of running a program unless there is a catastrophe! Such an event is likely to discourage to computer from functioning at all.

Now that we have 'random' numbers, what to do with them? Can they be manipulated to produce a set of numbers within a certain range? In short, yes they can. One technique is to PEEK consecutive addresses and accept the contents if they lie within a certain range.

Another way is to scale the numbers obtained. This sort of subroutine will produce 'random' integers in the range 1-10:

```
10010 FOR I=1 TO 100
10020 R=INT(PEEK(I)/25)
10030 PRINT R
10040 NEXT I
10050 RETURN
```

This subroutine will always produce the same 100 'random' numbers. There is no need to use an array to keep them safely; they are readily accessible.

This sort of technique may not suit your requirements when random numbers considerably larger than 255 are needed. One way of producing 'random' numbers up to 65535 is to add the contents of one address to 256 times the contents of another address:

```
10010 FOR I=1 TO 100
10020 R=PEEK(I) + 256*PEEK(I+1)
10030 PRINT R
10040 NEXT I
10050 RETURN
```

Another technique? Not a few programs involve branching if a condition is met. Perhaps something along these lines:

```
10 FOR I=1 TO 1000
20 IF PEEK(I)>204 THEN PRINT
   "HIGH"
30 NEXT I
```

Roughly 23% of the contents of the addresses are greater than 204, causing "HIGH" to be printed about 230 times. This information can be used to create random mazes at higher speeds than those created in this sort of way:

```
10 RANDOM
20 CLS
30 R=RND(11200)
40 FOR I=0 TO 1023
50 IF PEEK(I+R)>204 THEN POKE
   15360+I,191
60 NEXT I
70 PRINT@0,"READY";
80 GOTO 80
```

The program generates random numbers between 1 and 100. If the number is less than 24 then a graphic block is POKEd into the video RAM which starts at address 15360 and occupies 1024 bytes. This is done for all the 1024 addresses, resulting in a random maze of about 235 graphic blocks. The program occupies 135 bytes and takes about 20 seconds to produce the maze. Note that the maze is different every time that the program is run. Now try this program:

```
10 CLS
20 FOR I=0 TO 1023
30 IF PEEK(I)>204 THEN POKE
   15360+I,191
40 NEXT I
50 PRINT@0,"READY";
60 GOTO 60
```

This program occupies 113 bytes and takes about 10 seconds to produce the maze which is the same every time that the program is run.

Now suppose that you like the speed advantage but don't want the reproducibility of the maze? Simply start PEEKing from a different address, for example this program which takes up 126 bytes:

```
10 RANDOM
20 CLS
30 FOR I=0 TO 1023
40 R=RND(100)
50 IF R<24 THEN POKE 15360+I,191
60 NEXT I
70 PRINT@0,"READY";
80 GOTO 80
```

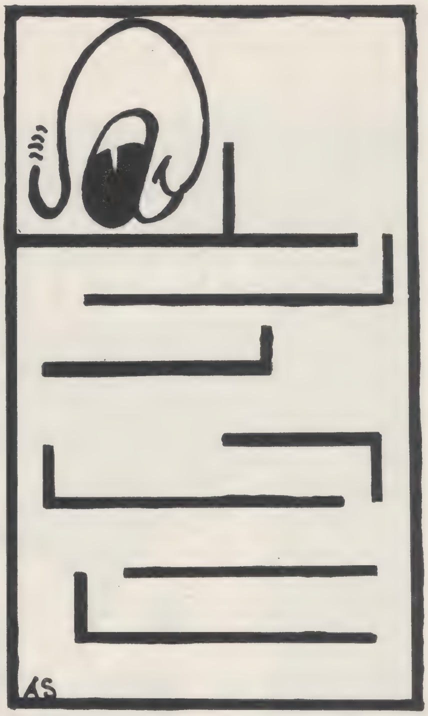
This program still occupies less memory than that in Listing 8 and takes about 13 seconds to produce a maze.

I have not exhausted all possibilities, such as the use of random numbers to produce random letters, but such delights I leave to you. However, as an example of a game which utilises reproducible random numbers, there is . . . ATMAN!

ATMAN-IA

The computer creates a maze through which a solitary figure is directed home by use of the numeric keypad. A bulky slow-witted ATMAN will probably try to stop its progress by jumping on it. Should the ATMAN succeed, you will be given another chance to try. In the event that you succeed, you will be given the chance to try against an increased number of ATMEN. The game continues until you give up or eventually defeat the maximum of 20 ATMEN.

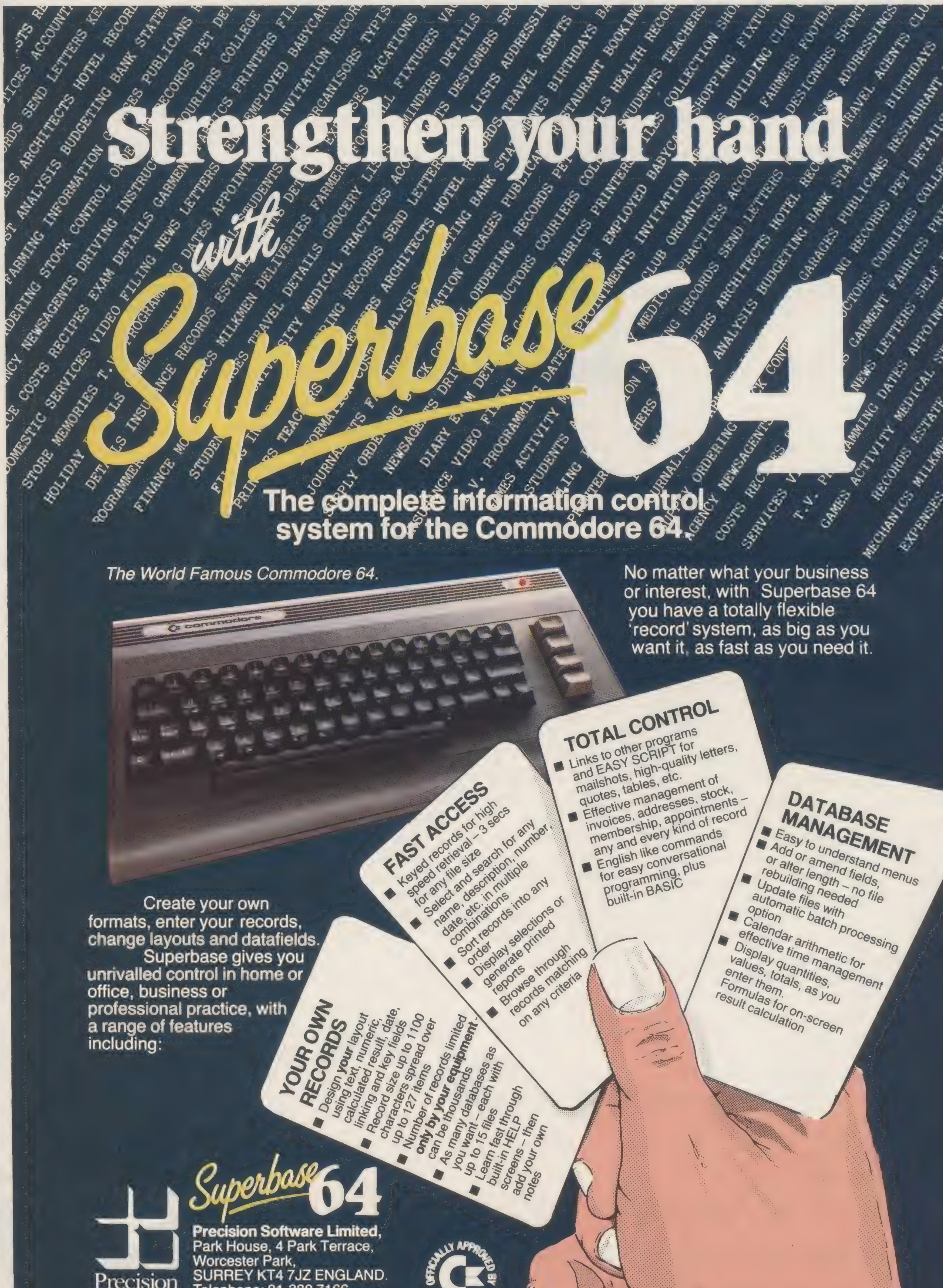
As it stands, the program occupies over 6K of RAM. By omitting REM statements and spaces it can be reduced to less than 4K. The copious REMs should make the program self-explanatory.



Listing 1. The ATMAN program.

```
10 REM ** ATMAN BY M.D. BUXTON 1983
20 REM ** INITIALIZE VARIABLES
30 DEFINT A-Z
40 REM ** START OF VIDEO RAM
50 C=15360
60 REM ** @ SYMBOL AND SCREEN WIDTH
70 C1=64
80 REM ** INCREMENT OF MOVEMENT
90 C2=1
100 REM ** GRAPHICS BLOCK
110 C3=191
120 RANDOM
130 REM ** ATMAN ARRAY
140 DIM R(20,3)
150 REM ** NUMBER OF ATMEN
160 NR=1
170 REM ** SET UP MAZE AND INSTRUCTIONS IF REQUIRED
180 GOTO 1970
190 REM ** BUILD UP HOME REGION
200 PRINT@31,"[4 SPC]";
210 PRINT@95,"[4 SPC]";
220 PRINT@159,"[4 SPC]";
230 REM ** THIS FORCES AN UPPER CASE 'X'
240 POKE 15436,88
250 REM ** BORDERS FOR MESSAGES
260 FOR Z=C2 TO 15
270 POKE C+C1+Z,C3
290 NEXT Z
300 REM ** BUILD UP PLAYER'S START
310 REM ** PLAYER IS 'O'
320 PRINT@860,"[5 SPC]";
330 PRINT@924,"[2 SPC]O[2 SPC]";
340 PRINT@988,"[5 SPC]";
350 REM ** SET KEYBOARD MOVEMENT NUMBER TO ZERO
360 K=0
370 IF NR=1 THEN PRINT@45,"*****************";
380 IF NR>1 THEN PRINT@0,"*";NR;"* ATMEN *";
390 GOTO 1780
400 REM ** PLAYER PROMPT
410 PRINT@45,"* YOUR * MOVE *";
420 REM ** HAS KEY BEEN PRESSED TO ALTER DIRECTION?
430 Z$=INKEY$
440 IF Z$="" THEN 510
450 REM ** KEYBOARD DIRECTION
460 REM ** THIS PREVENTS 'FREEZING' BY PRESSING 0,5
    OR A LETTER
470 L=VAL(Z$)
480 IF L=0 OR L=5 THEN 430
490 K=VAL(Z$)
500 REM ** AFTER SETTING UP, K SHOULD BE ZERO
510 IF K=0 OR K=5 THEN 430
520 REM ** NEW POSITION OF PLAYER
530 ON K GOTO 570,600,630,660,690,700,730,760,790
540 REM ** NEW CO-ORDINATES CALCULATED
550 REM ** TX IS NEW VALUE OF X
560 REM ** TY IS NEW VALUE OF Y
570 TX=X-C2
580 TY=Y+C2
590 GOTO 830
600 TX=X
610 TY=Y+C2
620 GOTO 830
630 TX=X+C2
640 TY=Y+C2
650 GOTO 830
660 TX=X-C2
670 TY=Y
680 GOTO 830
690 GOTO 1540
700 TX=X+C2
710 TY=Y
720 GOTO 830
730 TX=X-C2
740 TY=Y-C2
750 GOTO 830
760 TX=X
770 TY=Y-C2
780 GOTO 830
790 TX=X+C2
800 TY=Y-C2
810 GOTO 830
820 REM ** KEEP ON SCREEN
830 IF TX>63 THEN TX=63 ELSE IF TX<0 THEN TX=0
840 REM ** PREVENTING WRAP-AROUND
850 IF TY>16 THEN TY=16 ELSE IF TY<0 THEN TY=0
860 REM ** TP IS TO BE PEEKED (NEW LOCATION OF
    PLAYER
870 TP=C+TY*C1+TX
880 REM ** KEEP ON SCREEN
890 IF TP>16383 THEN 1110
900 REM ** CURRENT LOCATION OF PLAYER
910 PP=C+Y*C1+X
920 REM ** JUMPING TO WHAT?
930 TL=PEEK(TP)
940 REM ** SPACE
950 IF TL=32 THEN 1030
960 REM ** ATMAN
970 IF TL =C1 THEN 1540
980 REM ** HOME AND WIN
990 IF TL=88 THEN 1030
1000 REM ** WALL OR OTHER - NO MOVE
1010 GOTO 1110
1020 REM ** POKE PLAYER INTO NEW POSITION
1030 POKE TP,79
1040 REM ** POKE BLANK INTO PLAYER'S OLD POSITION
1050 POKE PP,32
```

```
1060 REM ** UPDATE
1070 X=TX
1080 Y=TY
1090 IF TL=88 THEN 1610
1100 REM ** REPLACE PLAYER PROMPT
1110 PRINT@45," ATMAN * MOVES ";
1120 FOR I=C2 TO NR
1130 REM ** CAN THE ATMAN MOVE? DELETE THE REM FROM
     LINE 1150 TO ALTER THE CHANCE OF AN ATMAN MOVING
     FROM CERTAIN TO 1 IN 3
1140 R(I,3)=-C2
1150 REM ** IF RND(10)>3 THEN R(I,3)=0
1160 NEXT I
1170 FOR I=C2 TO NR
1180 REM ** ASSIGN VALUES TO TEMPORARY VARIABLES
1190 REM ** BX IS HORIZONTAL CO-ORDINATE
1200 BX=R(I,1)
1210 REM ** BY IS VERTICAL CO-ORDINATE
1220 BY=R(I,2)
1230 REM ** MOVE FLAG NOT SET?
1240 IF R(I,3) THEN 1520
1250 REM ** HORIZONTAL AND VERTICAL DISTANCES
1260 REM ** DX IS HORIZONTAL DISTANCE FROM ITH ATMAN
     TO PLAYER
1270 DX=ABS(R(I,1)-X)
1280 REM ** DY IS VERTICAL DISTANCE FROM ITH ATMAN
     TO PLAYER
1290 DY=ABS(R(I,2)-Y)
1300 REM ** WHICH DISTANCE IS GREATER?
1310 IF DX<DY THEN 1360
1320 REM ** ADJUST HORIZONTAL DISTANCE
1330 IF R(I,1)>X THEN BX=R(I,1)-C2 ELSE BX=R(I,1)+C2
1340 GOTO 1380
1350 REM ** ADHUST VERTICAL DISTANCE
1360 IF R(I,2)>Y THEN BY=R(I,2)-C2 ELSE BY=R(I,2)+C2
1370 REM ** BP IS PROVISIONAL LOCATION OF ITH ATMAN
1380 BP=C+BY*C1+BX
1390 REM ** KEEP ON SCREEN
1400 IF BP>16383 OR BP<C THEN 1520
1410 BC=PEEK(BP)
1420 REM ** STUCK?
1430 IF BC=32 OR BC=79 THEN 1450 ELSE 1520
1440 REM ** MOVE ATMAN
1450 POKE BP,C1
1460 POKE (C+R(I,1)+R(I,2)*C1),32
1470 REM ** COLLISION
1480 IF BC=79 THEN 1540
1490 REM ** UPDATE
1500 R(I,1)=BX
1510 R(I,2)=BY
1520 NEXT I
1530 GOTO 410
1540 PRINT@(X+C1*Y),"SPLAT!";
1560 GOSUB 2530
1570 IF Z$<>CHR$(13) THEN 1560
1580 CLS
1590 PRINT "YOU HAVE FAILED."
1600 GOTO 1730
1610 PRINT@0,"  SUCCESS!!!  ";
1620 REM ** INCREMENT NUMBER OF ATMEN
1630 NR=NR+C2
1640 PRINT@512,"PRESS ENTER TO CONTINUE.";
1650 GOSUB 2530
1660 IF Z$<>CHR$(13) THEN 1650
1670 IF NR<21 THEN 1710
1680 PRINT@512,"YOU HAVE DEFEATED ALL OF THE ATMEN!
     WOULD YOU LIKE TO START AGAIN? Y/N "
1690 GOSUB 2530
1700 IF Z$="Y" THEN RUN ELSE END
1710 PRINT@512,"WOULD YOU LIKE TO TRY AGAIN WITH ONE
     MORE ATMAN? Y/N "
1720 GOTO 1740
1730 PRINT@512,"WOULD YOU LIKE TO TRY AGAIN WITH THE
SAME NUMBER OF ATMEN? Y/N"
1740 GOSUB 2530
1750 IF Z$="N" THEN END ELSE 1970
1760 REM ** SET UP ATMAN ARRAYS
1770 REM ** 20 ATMEN
1780 FOR I=C2 TO  NR
1790 REM ** RANDOM COLUMN
1800 RX=RND(C1)-C2
1810 REM ** RANDOM ROW EXCEPT TOP
1820 RY=RND(15)
1830 REM ** LOCATION IN MEMORY
1840 RL=C+RX+C1*RY
1850 REM ** SPACE FOR ATMAN
1860 IF PEEK(RL)<>32 THEN 1800
1870 REM ** X CO-ORD
1880 R(I,1)=RX
1890 REM ** Y CO-ORD
1900 R(I,2)=RY
1910 REM ** FLAG FOR MOVEMENT
1920 R(I,3)=0
1930 NEXT I
1940 IF NR=1 THEN PRINT@0," * ONE * ATMAN ";
1950 REM ** PLAYER PROMPT
1960 GOTO 410
1970 CLS
1980 PRINT"ATMAN GAME"
1990 PRINT"@@@@@@@@@@"
2000 PRINT
2010 PRINT"WOULD YOU LIKE INSRUCTIONS? Y/N "
2020 GOSUB 2530
2030 IF Z$="N" THEN 2290
2040 CLS
2050 PRINT" I WILL PRINT A RANDOM MAZE COMPRISING
     SPACES
     WALLS            ";CHR$(C3);"
     ATMEN            @
     A HOME           X
     AND YOURSELF     O"
2060 REM ** THESE POKES FORCE THE CORRECT CHARACTERS
     IF THE LOWER CASE DRIVER PROGRAM OF SEPTEMBER
     '82 CT IS BEING USED
2070 POKE 15505,C3
2080 POKE 15633,88
2090 PRINT
2100 PRINT"USE THE NUMERIC KEYPAD TO DIRECT YOUR MOVE
MENT AND EVENTUALLY GET HOME."
2110 PRINT
2120 PRINT"7=UP AND LEFT     8=UP     9=UP AND RIGHT"
2130 PRINT
2140 PRINT"4=LEFT                     6=RIGHT"
2150 PRINT
2160 PRINT"1=DOWN AND LEFT   2=DOWN   3=DOWN AND RIGH
T"
2170 PRINT
2180 PRINT
2190 PRINT"USING ANY OTHER KEY WILL NOT WIN THE GAME
FOR YOU!"
2200 PRINT"PRESS ANY KEY TO CONTINUE."
2210 GOSUB 2530
2220 CLS
2230 PRINT"*HITTING THE KEYS RAPIDLY WILL NOT RESULT
IN FASTER MOVEMENT*YOU MAY ALTER DIRECTION WHEN YOU
HAVE SEEN THE * YOUR MOVE * MESSAGE APPEAR IN THE TOP
RIGHT HAND CORNER OF THE SCREEN."
2240 PRINT"FAT ATMEN WHICH CAN'T GET BETWEEN DIAGONAL
LY JOINING WALLS (UNLIKE YOU) WILL TRY TO JUMP ON YOU
! THEY ARE PERSISTENT BUT NOT VERY INTELLIGENT. THEY
ARE NOW HIDING IN THE WALLS.";
2250 PRINT" SOME OF THE MORE DEVIOUS ATMEN WILL NOT A
PPEAR IMMEDIATELY. SOME WILL WAIT, HOPING THAT AS YOU
PASS THEY WILL BE ABLE TO JUMP ON YOU IN A SURPRISE A
TTACK! LESS PATIENT OR EVEN LESS INTELLIGENT ATMEN WI
LL APPEAR FOR NO APPARENT REASON."
2260 PRINT"PRESS ANY KEY TO CONTINUE."
2280 GOSUB 2530
2290 CLS
2300 REM** CO-ORDS FOR PLAYER START
2310 X=30
2320 Y=14
2330 CLS
2340 PRINT"PRESS R FOR A RANDOM MAZE. PRESS ANY OTHER
KEY FOR AN UNCHANGING MAZE."
2350 GOSUB 2530
2360 IF Z$<>"R" THEN 2460
2370 CLS
2380 REM ** SELECT ROM AREA
2390 R=RND(11200)
2400 FOR P=R TO R+1023
2410 REM ** WALL OR SPACE
2420 IF PEEK(P)>220 THEN POKE (P-R+C),C3
2430 NEXT P
2440 REM ** RANDOM MAZE DONE
2450 GOTO 200
2460 CLS
2470 REM ** THIS IS TO CREATE AN UNCHANGING RANDOM
     MAZE
2480 FOR P=0 TO 1023
2490 IF PEEK(P)<25 THEN POKE C+P,C3
2500 NEXT P
2510 GOTO 200
2520 REM ** KEYBOARD SCAN ROUTINE
2530 Z$=INKEY$
2540 IF Z$="" THEN 2530 ELSE RETURN
2550 END
```



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